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FUNGOID DISEASES OF IMPORTANT CROPS IN MADRAS PRESIDENCY

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PREFACE

A handbook of Fungus Diseases of Crops in Madras Presidency has been a long-felt want and the present one is the outcome of the decision arrived at a meeting of the officers of the local Agricultural Department in 1930.

This handbook lays no claim to originality but epitomizes the work of the Mycological Section of the Madras Department of Agriculture during the last quarter of a century and is based mainly on trials made and observations recorded on such diseases as have come within its purview. Materials which lie scattered in several publications of the department have been drawn upon, compiled and edited.

It is not intended to be a text-book but is meant only to serve as a guide to those interested in agriculture. It is a popular account of the occurrence, distribution and incidence of the diseases referred to with the measures found useful and practicable under Madras conditions.

The authors will feel amply rewarded if it awakens more interest in the study of mycological problems than at present and helps in the adoption of measures which will reduce losses in yields of crops.

S. SUNDARARAMAN
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FUNGOID DISEASES OF IMPORTANT CROPS IN MADRAS PRESIDENCY.

CHAPTER I.

Introduction.—Every farmer knows that plants are subject to diseases that considerably reduce his crop yields. In South India the heavy toll which the cultivator pays annually to crop diseases has been estimated to amount to more than ten million rupees from five diseases only. The red-rot of sugarcane, the smuts of cholam, the blast disease of paddy, the bud-rot of palmyra and coconuts, the mildews of fruit crops like grapes and mangoes are a few of the more important of plant diseases which have assumed serious proportions in the Madras Presidency. Almost every crop plant is subject to one kind of disease or another, though only under certain exceptional circumstances the disease assumes an epidemic form causing enormous damage to draw the attention of the cultivator.

Before discussing plant diseases, it is necessary to know something of the normal life of the plant, its mode of life, the manner in which it takes its food materials and its relation to its environment.

Plant life.—A normal crop plant is green. One part of it grows in the air and one part grows in the soil. It sends down its roots in the soil and with their aid absorbs food materials which are dissolved in soil water. The soil water supplies to the plant besides hydrogen and oxygen (constituents of water) the elements—nitrogen, phosphorous, sulphur, calcium, chlorine, iron and potassium, which are essential for the plant. These are taken in the form of salts dissolved in water as nitrates, phosphates and sulphates. One of the chief constituents of the plant body, namely, carbon, is obtained from the air through the green leaf in the presence of sunlight. The green colouring matter of the leaves is able to obtain the carbon the plant needs from the carbon dioxide present in the air in the presence of sunlight. The plant is able to form the complex substances it needs for its growth and reproduction from these simple substances. It is evident from the foregoing that, if a plant should be healthy, its relation to its environment, namely, the soil and the air, should be of a satisfactory nature. The soil must be in a good condition to allow the roots to get between the soil particles and absorb the soil water. Since the roots are living bodies, the soil should not be water-logged as free aeration is essential for a healthy root system. So an ideal soil condition will be that which provides enough soil moisture for supplying food materials to the plants and at the same time does not interfere with the free aeration of the roots.

In the same manner the leaves must have plenty of sunlight falling on them and at the same time should not suffer from excessive heat.

The absence of one or more of the mineral ingredients which are essential to plant growth will also tell on the health of the plant.

To summarize, to be normal and healthy, (*a*) a plant must have its roots and foliage in a good condition, (*b*) it must have all the necessary ingredients in an easily available form in the soil, (*c*) it must have enough soil moisture to supply its needs which should not however be in excess so as to interfere with its root system and (*d*) it must also have enough sunlight and air.

Good spacing, manuring, judicious watering, adequate drainage and soil tilth are therefore indispensable for growing healthy crops. If any one of these factors is insufficient or fails, the crop suffers even though no disease-producing organism is present. But such an organism when present easily invades weak plants and sets about its task of destroying the plant.

Plant diseases.—A plant is said to be diseased when, owing to some environmental conditions or due to the presence of associated organisms, it is not able to display its normal state of development. In its widest sense the term ' disease ' may include insect depredation, but ordinarily it serves to designate plant troubles caused by fungi, bacteria, virus or the disturbance of the normal life of the plant due to some physiological reasons.

We shall in this book deal chiefly with diseases caused by fungi though incidentally mention will be made of a few virus diseases. As a preliminary to the study of crop diseases, it is necessary one should know something of fungi in general, the scope of their organization, the methods of their distribution, etc.

What are fungi?—The fungi are plants low down in the scale. Unlike ordinary plants they are not green and cannot manufacture their own food out of the simple compounds found in the air and the soil. Fungi depend on living plants or dead organic matter for their food. They are therefore either parasites or saprophytes according as whether they live on living or on dead organic matter.

Saprophytes.—Saprophytes render decaying animal and plant tissues useful by converting them into simple plant food once again.

Parasites.—Parasites attack and obtain their nourishment from living plants and animals. This group includes all those fungi and bacteria which cause definite plant diseases. Sometimes an organism normally a saprophyte may invade and produce disease in a plant the vitality of which is low due to poor growing conditions, when it is called a hemi-parasite. Some parasites are weak and can infect their host plants only when conditions are extremely favourable, e.g., a wound on the surface of the host. But many are strong and are able to pierce through the tissues of the host plants and cause infection even without a wound. A few parasites are incapable of living apart from their hosts. Others, though parasites normally, are capable of living on dead organic matter and thus tide over a season in the absence of the host plant.

Fungi.—Fungi are intimately associated with man's life though owing to their small size their importance is not ordinarily recognized. The moulds which attack stored products, the smuts that appear on cereals, the yeast used in breweries, the ergot used in medicines and mushrooms are familiar examples of fungi.

Fungi differ from ordinary plants in that they are not green. Green plants are able to produce all the complex food products they require from the simple compounds found in the air and in the soil with the aid of sunlight. The structure and the mode of life of a fungus are adapted for its obtaining nourishment direct from sources where it finds its nutrition ready made. Most fungi are minute organisms, though a few like the mushrooms are large. Detailed study of a fungus requires the aid of a microscope.

The vegetative part of a fungus is known as the mycelium and consists of slender, cylindrical, thread-like filaments. These are very fine and delicate, their diameter is usually about 1/5000 of an inch. A single thread of a mycelium is known as a hypha. The inside of the filament may all be one continuous cavity as in some of the moulds, or as in all higher fungi it may be divided by partitions (or septa) into a number of cells. The form assumed by most of the simple fungi consists of an interlaced mass of mycelial threads.

The hyphæ spread themselves in the substrata and imbibe food materials which they find in a readily assimilable form either in their host tissues or other organic matter. The fungi reproduce themselves by means of minute seedlike structures called spores. In their function the spores correspond to the seeds of higher plants. These spores are very minute bodies which are produced in enormous numbers. When a spore finds a suitable substratum and the necessary conditions of humidity and warmth, it germinates and gives rise to a mycelial growth.

Some fungi do not produce spores under ordinary conditions but form compact hard masses of hyphæ when they are known as sclerotia.

Spores are of different kinds. They may be one-celled, two-celled or many-celled. Their shape and size vary in different fungi. The shape and the size of a spore are the chief means of distinguishing one fungus from another.

Spores may be formed either *asexually* by being budded off from the growing ends of hyphæ or by the union of sexes. In most fungi the sexual phase is absent and spore formation is only an asexual process.

Examples of fungi.—The mushrooms are examples of large fungi. They are seen growing in fields and on manure heaps after a rain. The mushrooms are not harmful to crops, and a few of them are even edible. The mycelial growth of the mushroom is mostly underground. The portion that is seen above the soil bears spores.

The common moulds which spread on our food-stuffs sometimes in wet weather are other examples. Moulds are of various kinds—blue mould, green mould, black mould, etc.

The mildews that affect roses, grape-vine and mango, the smuts of cholam, the rusts of cereals are examples of fungi which cause plant disease.

Infection.—Some fungi like the mildews first spread themselves on the surface of the host plants and then penetrate the living tissues with the minute structures which develop into what are termed, *haustoria* (food-absorbing structures). Others penetrate through the host tissue in various ways through stomata, lenticels, wounds or abrasions on the surface, through cut ends and sometimes directly through piercing the outer epidermal layer. In most cases moisture in abundance is necessary for the germination of the spores though a few are able to germinate even in a slightly humid atmosphere.

Too much emphasis cannot be laid on the fact that besides the presence of disease causing fungus (or pathogen) there are a number of other factors which have to be taken into consideration before a plant becomes diseased. The vitality of the plant, the nature of the soil, the weather conditions and manurial factors, all have a bearing—and a very important bearing—in inducing disease conditions in plants. So it is possible to circumvent a number of diseases by creating conditions for the plant which enable it to get over the disease or vice versa, e.g., weakened growths resulting through growing crops in ill-drained and faultily irrigated lands would often afford facilities for the invasion of pathogenic organisms.

CHAPTER II.

Effect of fungi on plants.—The preceding pages have dealt with the causes of plant diseases. Symptoms of disease are discussed in this chapter:—

(1) *Leaf-spot.*—The fungus causes destruction of tissue causing isolated circular spots on the foliage which ultimately turn brown and sometimes break off leaving holes. Such spots on leaves affect the general health of the plant. Example: Tikka in groundnut.

(2) *Rusts.*—The leaves are dotted with orange brown or black coloured spots. The spots when examined under a lens are seen to be eruptions of the epidermis of the leaf in which spores are found clustered. These eruptions burst after some time exposing the spores. Example: Rust on cholam.

(3) *Destruction of entire organs.*—In some cases the leaves turn yellow, rot and fall off. Entire earheads of grains may be replaced by the fungus as in the case of the smuts. Example: Smut on cholam.

(4) *Change of habit.*—The part of the host attacked by the fungus behaves in a peculiar manner, e.g., the whole mass of branches, instead of normally spreading, look like little brushes as if rising from one point of the plant.

Plants that are usually of prostrating or creeping habit may, by the attack of fungus, get an erect habit. Example: *Ipomœa reniformis* (a weed in paddy lands).

(5) *Destruction of the entire plant*—(*a*) *Damping off of seedlings.*—When seeds are sown too close they are liable to fungus attack. The little seedlings lose colour and bend over at the collar region and in course of time rot. This phenomenon is called the damping off of seedlings, and is caused by the Pythiums and Phytophthoras.

(*b*) *Wilting.*—The entire plant wilts, i.e., its leaves become flaccid and droop down as if for want of water. Wilting is usually the result of a fungus attack at the root region or the collar region. The mycelium of the fungus fills the vessels (water-conducting tubes in the plant) and water-supply is cut off to the stems and branches. In course of time the wilting plant begins to rot and the plant seldom survives. Example: Cotton wilt, red-gram wilt, etc.

(6) *Leaf curl.*—The fungus causes leaf tissues to grow irregularly and thus the leaf assumes a crinkled or curly appearance. Example: Peach leaf curl.

(7) *Leaf shredding.*—The green parenchymatous tissue between the vascular bundles is invaded by the fungus and gets destroyed causing the shredding of leaves. Example: Cholam leaf shredding.

(8) *Proliferation* is the name given to the abnormal multiplication and malformation of parts of plants. Example: Green ear disease of cumbu and tenai. The earheads instead of forming normal grains get transformed into a loose green head consisting of small twisted leaves.

(9) *Stimulation of host plants.*—The presence of the fungi stimulates localized growth of tissue in the plant body or causes swellings forming galls. Example: Galls on *Acacia leucophlœa.*

(10) *Rotting* of plant parts is the state of decomposition or decay usually associated with the formation of foul-smelling substances. Several kinds of rot are distinguished as dry rot, soft rot and black rot. In dry rot the affected plant begins to decay without exudation of moisture. In soft rot or wet rot the decay is associated with exudation of moisture. In black rot the affected part becomes black. Example: Dry rot of timber, black rot of coffee.

(11) *Fruit-rot.*—The fungus attacks young fruits causing rotting and the fruits drop down. Example: Mahali of arecanut and chillie fruit-rot.

(12) *Bud-rot.*—The fungus attacks leaf sheaths and works its way through till it reaches the bud or the growing point which it kills. Rotting sets in rendering the bud into a putrefying, foul smelling mass of dead tissue.

(13) *Red-rot.*—The fungus invades the stem causing a red discolouration of the tissue which in course of time rots and emits a sour odour. Example: Red-rot of sugarcane.

(14) *Die-back.*—The terminal twigs of a tree or shrub lose their foliage and wither. Example: Citrus die-back.

(15) *Mildew.*—The fungus spreads on the surface of the leaves and stem causing a white mealy appearance as if some white mealy powder has been strewn on the surface. Example. Tobacco and grape mildew.

(16) *Scab.*—The growth of the parasite on the surface or near the surface of the host plant stimulates the growth of tissues round about causing a thickening of the outer layer of the part affected. Example: Citrus scab.

(17) *Smut.*—In the case of some smuts the fungus grows from within the host plant having been associated with it from the seed stage, but makes itself known only after the flowers are produced. In others it enters through the flower and the axils of leaves.

(18) *Sooty mould.*—Certain fungi which are associated with the insects known as the scale insects spread on the foliage of the host plant and the leaves present an appearance of being covered with a layer of soot. Their mycelium is dark brown in colour. The dark mass of hyphæ prevents sunlight reaching the green leaves thus interfering with the manufacture of food. Example: Sooty mould on mango, guava.

Resistance, tolerance and immunity.—Certain plants are highly susceptible to certain diseases and a very large percentage of the population is prone to be attacked when a disease is prevalent. Others are resistant, that is, a larger proportion of them escape the disease. A few are immune, i.e., the disease leaves them severely alone. Again, others may get infected but do not suffer. These are said to be tolerant. A plant, therefore, may be susceptible, resistant, immune or tolerant. What makes one plant resistant and another susceptible is not yet fully understood. The resistance to plant diseases may be due to morphological or histological peculiarities like the presence of protecting chemical bodies; or some specially favourable physiological characters. The habit of earliness or lateness of the plant may also be determining factor in resistance and again in very many cases the resistance is due to the fact that the plant dries quickly after a rain. It would appear that resistance against particular diseases may be possessed by individuals or groups of individuals. While a certain plant may be immune against one disease it may be highly susceptible to another.

Distribution of disease.—The extent of the local distribution of the disease is governed by numerous factors such as temperature, rainfall, abundance of the host, methods of dissemination, etc.:—

(1) Temperature and rainfall exert a great influence on the distribution of diseases caused by fungi. A humid warm climate encourages fungoid growth and renders host plants susceptible and the disease spreads quickly from field to field.

(2) Relative abundance of the host. If the crop is sparsely distributed, great distance separating one field from another, it may take a long time before the disease spreads throughout the area. The spread will also depend on the presence of an alternative host which would help the carrying over of the disease from one season to another. When a crop susceptible to a disease is grown year after year in an infected area, the chances of the disease establishing itself in the locality are very great and hence the need of a judicious rotation. This is specially true in cases of many diseases caused by soil fungi.

(3) Methods of dissemination. The methods of dissemination of bacteria or fungi are also factors on which depends the spread of the disease. An insectborne disease for instance soon spreads within the limits of the distance of the flight of the insect. Windborne diseases spread to considerable distances especially in the windward direction. Some fungi which are dependent on dissemination of their spores in rain splashes for their spread are naturally confined within local limits. Waterborne diseases on the other hand may spread the disease along the course of water channels.

CHAPTER III.

Control measures may conveniently be considered under the following heads:—

(1) Plant protection—
  (*a*) Spraying. (*b*) Seed disinfection.
(2) Resistant varieties.
(3) Field sanitation.
(4) Rotation of crops.
(5) Quarantine regulations.

Plant protection.—Under this head comes the use of fungicides which destroy the fungus and protect the plant from its attack. The fungicide must be (1) capable of destroying the parasite, (2) non-injurious to the plant, (3) easy to apply, (4) easy to prepare and (5) reasonable in cost. The first two of course, are obviously the most important though the latter also have to be taken into consideration when any spraying is done. The cost of spraying is a very important factor in the control of diseases. It will of course vary in different localities and for different parts and its efficacy will depend not on its intrinsic worth but on the relative increased yield which spraying gives. Fungicides are applied on the foliage and the aerial parts of the plant as liquid sprays or dusts with the aid of mechanical contrivances like the sprayers and dusters, or as seed disinfectants in which case the seed is steeped for a time in the fungicide before sowing. Fungicides are also directly applied to the soil as soil disinfectants.

A few of the most important fungicides now in common use in this Presidency are described below.

Bordeaux mixture.—The discovery of this fungicide was made in 1882 and was due to an accident. It has proved to be the most widely used and efficient fungicide so far discovered. Bordeaux mixture consists of a mixture of copper sulphate and lime. The lime precipitates the copper out of the solution till practically no copper remains in the solution. When this is sprayed on the plant a very thin film of this precipitate spreads on the tree. The fungicidal action of the mixture depends on small quantities of soluble copper liberated from time to time by the action of atmospheric carbon dioxide and other agencies. This copper in an ideal mixture is just sufficient to kill the fungus spores but not enough to adversely affect the foliage of the host plant.

Method of preparation.—Bordeaux mixture may be prepared in various strengths ranging from ½ per cent to a maximum of 2 per cent copper sulphate in solution.

Formulæ.

Copper sulphate.	Lime.	Water.
LB.	LB.	GALLONS.
2½	2½	50
5	5	50
6	4	50
10	10	50

The requisite quantity of copper sulphate is weighed, powdered and dissolved in half the quantity of water required in a wooden, copper or mud vessel. Preferably, the copper sulphate may be tied up in a piece of gunny and left to soak in water the previous night. Call this solution A. The required quantity of fresh, well burnt quicklime containing 90 per cent calcium oxide is at first slaked with a small quantity of water. After the entire quantity of lime is well slaked, more water is added to make up to half the total volume required for the mixture. Let us call this solution B. Now we have two solutions, A, copper sulphate in half the quantity of water and B, lime in half the quantity of water. A and B are poured into a third vessel the fluid being stirred vigorously all the time the Bordeaux mixture is made. It is advisable that this procedure is carefully followed since variations may lead to disastrous results, e.g., on no account should concentrated solutions of the two ingredients be mixed with each other.

Bordeaux mixture should be used as soon as possible after preparation since it loses its gelatinous property after some time. If the lime used is of poor quality copper sulphate will remain in solution and this is injurious to foliage. To make sure it is better to test the mixture before spraying by inserting a clean knife blade into the solution and allowing it to remain there for a few minutes. When the knife is withdrawn there should be no reddish tinge (coating of copper) on the knife blade. The reddish tinge on the blade indicates that more lime should be added.

Bordeaux mixture with resin-soda.—When spraying has to be done in the rainy season it is advisable to add a convenient adhesive to the mixture to prevent the spray being washed down by rain. Resin-soda is an excellent adhesive for Bordeaux mixture and is prepared as follows:—

Formula.

Resin.	Soda.	Water.
LB.	LB.	GALLONS.
4	2	2

for every 98 gallons of Bordeaux mixture (to make 100 gallons) and for lesser quantities in the same proportion.

Soda is put in an earthenware or iron pot with the required quantity of water and heated over a slow fire till the water is brought to boil. Powdered resin is added in small quantities at a time till the whole of the required quantity of resin is dissolved. The mixture should be stirred vigorously and boiled at least for an hour, till the liquid becomes perfectly clear. The resin soda mixture is allowed to cool and added to the copper lime mixture little by little, care being taken to stir the mixture vigorously all the while. The Bordeaux mixture is ready for use.

Fish-oil-resin soap is another adhesive which may be used with Bordeaux mixture. It has the additional advantage of being an insecticide as well.

For every 10 gallons of Bordeaux mixture, 1 lb. or less of fish oil resin soap is added.

Casein is another cheap and effective adhesive.

Alum Bordeaux mixture—Formula.

Copper sulphate.	Alum.	Lime.	Water.	Casein.
LB.	LB.	LB.	GALLONS.	LB.
4	4	6	50	1

To prepare 50 gallons of the mixture, 4 lb. of copper sulphate and 4 lb. of potash alum are dissolved in 24 gallons of water in a copper, wooden or earthenware vessel (A). 5 lb. of quicklime is dissolved in 24 gallons of water (B).

A and B are mixed, the mixture being stirred well all the while. Casein 1 lb. is soaked in water (1 gallon) and dissolved in lime water (1 gallon of water and 1 lb. of lime) and this solution is added to the alum-Bordeaux mixture as adhesive.

Copper sulphate or blue stone by itself is an effective fungicide but should never be used to spray green foliage. As a seed disinfectant, however, it is without an equal in controlling diseases like the smuts. Usually a 2 per cent solution is used though in many cases a 1 per cent solution is as effective.

Sulphur dusting is a well-known remedy against certain fungus diseases like the Mildew. Sulphur dust is obtained either as flowers of sulpher or ground sulphur. It must be in a very fine state of powder to be effective. On the fineness of the particles, to a great extent depends its adhesiveness and fungicidal value. A grade of sulphur which will pass through a sieve of 200 mesh per inch is recommended.

Formalin is a solution in water of 40 per cent Formaldehyde. It is usually used as a 1 per cent solution. It is a powerful fungicide. It is chiefly used for sterilizing seeds but can also be used as a spray on foliage in a very dilute solution (0·5 per cent).

Quicklime is often used to disinfect the soil against fungi which invade the plant from the soil. A dressing of 1,000 lb. to a ton of lime per acre is recommended. The lime is applied a few days prior to sowing.

Lime-sulphur sprays—Formula.

Lime.	Sulphur.	Water.
LB.	LB.	GALLONS.
2	4	2½

Two pounds of quicklime is first slaked in water in a kerosene tin. Two and a half gallons of water is added to it and is placed over a fire. When the water has begun to boil 4 pounds of flowers of sulphur is added little by little so that water and sulphur get well mixed up. The fluid should be kept continuously stirred. The mixture is boiled till the entire quantity of liquid gets a dark brown colour. (This will be in about an hour.)

Caution.—The mixture should never be allowed to become green

The liquid is filtered through a piece of gunny and kept ready for use. Before spraying it is made up to 20 gallons by the addition of water. Stock solutions may be prepared and preserved by keeping them in air-tight containers. A layer of mineral oil* on the top will effectively serve this purpose. This spray is used against ‘ Mildews.’

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* Kerosene oil.

Cheshunt compound is a solution of ammonium carbonate and copper sulphate in water. It is used as a soil disinfectant against weak parasites. It is prepared as follows:—

Ammonium carbonate—11 oz.
Copper sulphate—2 oz.

Weigh the above quantities of the chemicals and powder them well in a mortar till they are thoroughly mixed together and keep the mixture in a glass stoppered bottle until required for use. This mixture is to be used at the rate of 1 oz. in two gallons of water.

Field sanitation.—The importance of field sanitation in keeping out diseases cannot be over-emphasized. It is specially important to the bigger land-owner, the horticulturist and the orchardist who may with great advantage pay attention to it. It is needless to point out that in the case of many of the fungoid diseases keeping the field or orchard in a clean condition is one of the requisites of disease prevention. Removal of all sources of infection by means of which diseases are carried over from one season to the next is highly important. A number of fungoid diseases can be prevented in this manner. Even when spraying is done it is essential to remove all diseased and dying branches before the spray is applied. These should not be thrown about in the field but promptly burnt. When a plant succumbs to a root disease it is essential that it is dug out and all the affected tissue removed and the pit filled with lime. If necessary a trench may be dug round the infected area to prevent the invasion of the fungus into the roots of the neighbouring healthy trees. The soil dug out from the trenches should be thrown on to the infected side and not on the other side. Weeds of all kinds should be removed because they may act as alternative hosts to the disease organisms and harbour the disease till the time arrives when conditions are favourable for the spread of the disease.

Wound treatment.—When a branch is cut the exposed wound offers an excellent starting place for many fungoid diseases. Hence it is necessary to protect such exposed surfaces from the invasion of spores. Nature has provided the plant with enough resources to heal up wounds but it is essential that we should aid the healing up. Whenever a branch has to be cut, it is necessary to make a smooth sloping cut of the surface to avoid water to accumulate wherein the spores of harmful fungi find a convenient place to germinate. The cut surface has to be painted with antiseptics like tar.

Seed protection.—Many diseases notably the smuts are carried over from one place to another and from one season to the next by means of the spores which adhere to the seeds of the host plants. In such cases the seeds are treated with fungicides which kill the spores without injuring the seeds. Copper sulphate solution is an excellent fungicide to control smuts. Formalin and Bordeaux mixture are also used as seed disinfectants in other cases.

Sett selection.—In cases like the red-rot of sugarcane, the disease is perpetuated chiefly through planting diseased setts. By a careful selection of healthy setts for planting purposes the disease can easily be controlled. Sugarcane mosaic is another example of a disease which can be controlled by sett selection. Special care should be taken in planting orchards, to see that cuttings do not carry any disease.

Rotation of crops.—When a crop is gorwn year after year in the same field, the chances of fungoid diseases firmly establishing themselves are very great. This is especially true in diseases caused by soil dwelling fungi like the Fusaria. Crop rotation, therefore, is in many cases an essential thing to combat plant diseases. In many cases, owing to the nature and habit of the fungi no other method of control is feasible. When rotation is practised, the pathogenic fungus does not find a continuous source of food supply from its host plant and is gradually starved out. A sufficient interval must intervene two successive crops of the same kind. It should be borne in mind that crops resembling each other as the different pulses for example are subject to the same disease.

*Plant quarantine**.—When seeds and plants are obtained from a new locality, it is necessary that we make sure that no disease is carried along with them. So they must be carefully examined and fumigated before being planted. They should in the first instance be planted in isolated places for a sufficient period, to ensure that no disease is present. In case any disease shows itself out the plants must be completely destroyed by being burnt.

In importing seeds and plants from foreign land special care should be taken and the law of the land must have powers to prevent importation of seeds and plants which are likely to bring new diseases with them.

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* The term quarantine literally meaning forty days was originally designated as the time during which a ship suspected of being infected with disease was obliged to refrain from approaching the shore.

CHAPTER IV.

CROP DISEASES.

PADDY. *

Piricularia oryzæ (*Blast*).

Tamil—Kollai novu.
Telugu—Aggi tegulu.

By far the most important disease of paddy in South India is the Blast disease caused by a fungus *Piricularia oryzæ*. In its typical form it is the disease of the joints of the stalk. In the case of young plants brown spots with ash gray centres appear on the leaves. In course of time the spots grow larger and larger and coalesce to form big patches on the leaf. After some time the entire leaf blade turns brown and shrivels up. When attack is on older plants the leaf spots do not spread so rapidly. Infection is more severe at the joints. In severe cases the stalk joints are attacked especially the ‘ neck,’ the spot where the stalk passes into the axils of the panicle. In such cases the grains are poorly developed and sometimes the panicle breaks off at the diseased spot. In a badly affected field the entire crop has a blasted appearance. On the whole the fungus is a very dangerous one and the loss it can cause is indeed very great. (Fig. 1.)

There is evidence to prove that excessive use of nitrogenous fertilizers aids the disease. Spraying with Bordeaux mixture may control the disease in the nursery but is utterly impracticable in the case of the transplanted crop. The only method to combat the disease is by avoiding susceptible varieties and growing resistant varieties. Fortunately a few strains of paddy released by the Department of Agriculture, Madras, are highly resistant and can be grown in localities where the disease is prevalent. The following varieties are highly susceptible and should be avoided in places where Piricularia is imminent: Korangu samba, A.E.B. 3, Co. 6, Adt. 6.

The following strains are highly resistant:—
G.E.B. 24, Co. 1, Co. 4.

It is present in the districts of Tanjore, Trichinipoly, Coimbatore, South Arcot, North Arcot, Chittoor, Nellore, Kurnool and Bellary.

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* *Oryza Sativa.*

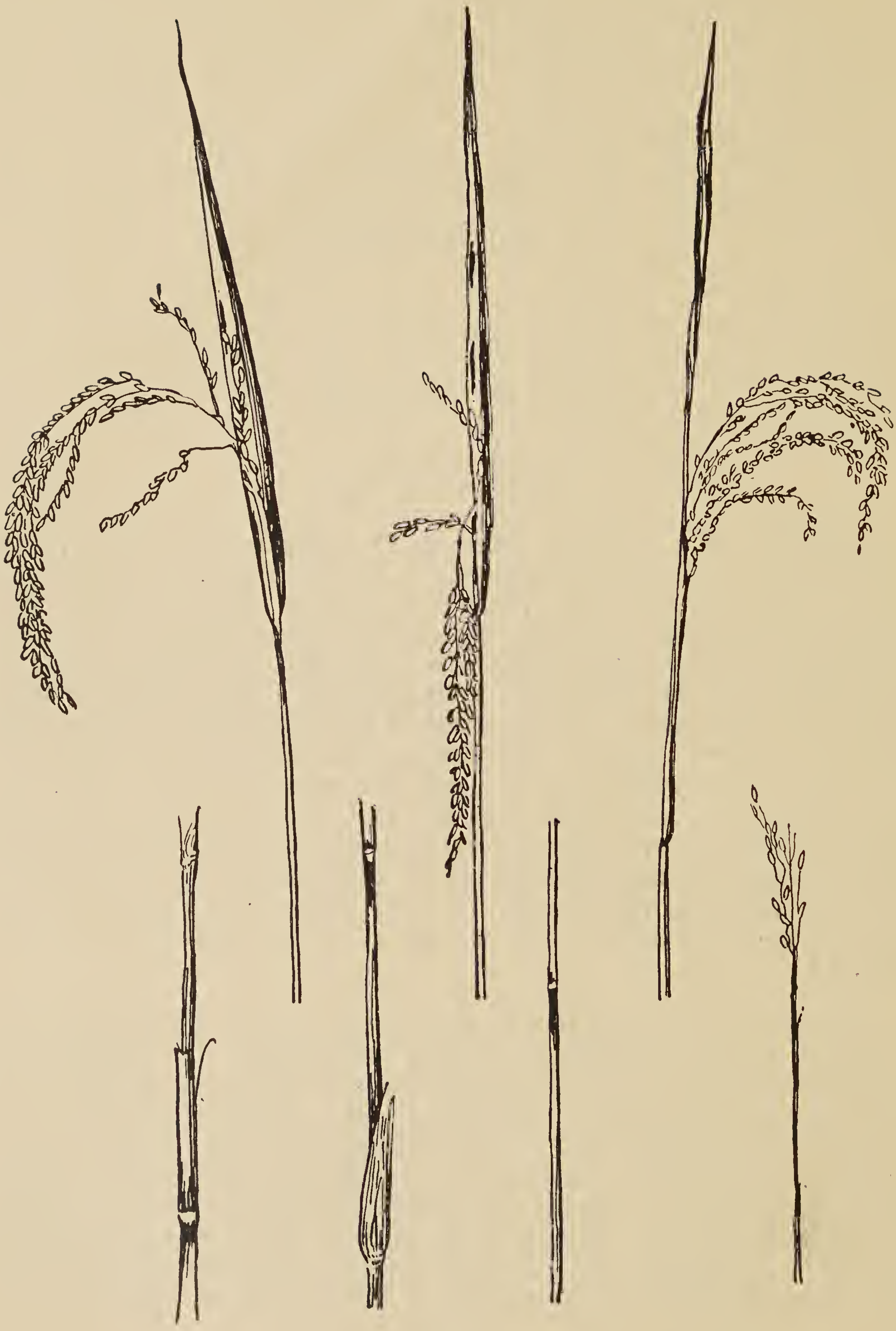


Fig. 1
Paddy Piricularia.
Neck and node.
(Courtesy—*Madras Agricultural Journal.*)

See page 13.

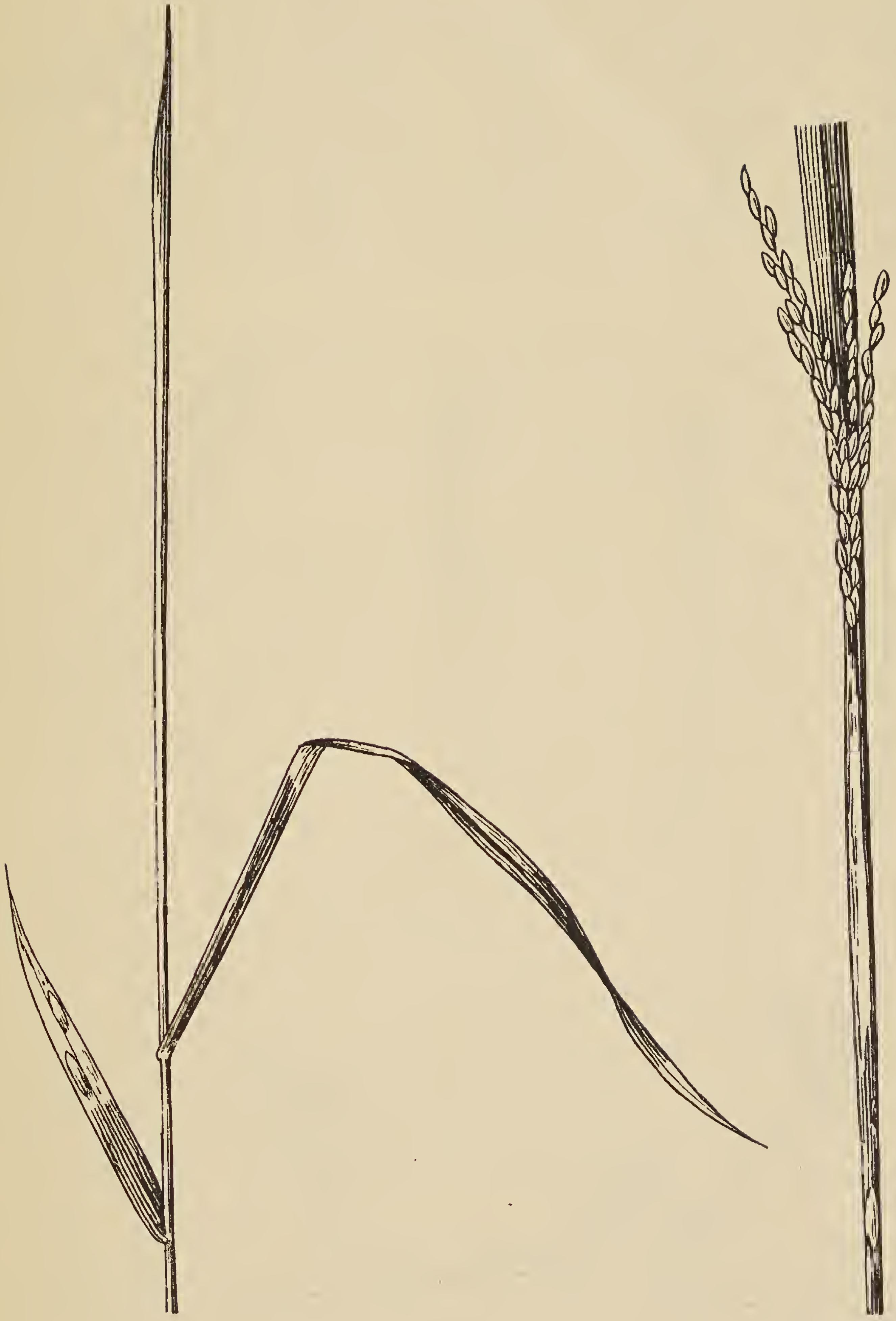


Fig. 2.
Helminthosporium on paddy. See page 17.

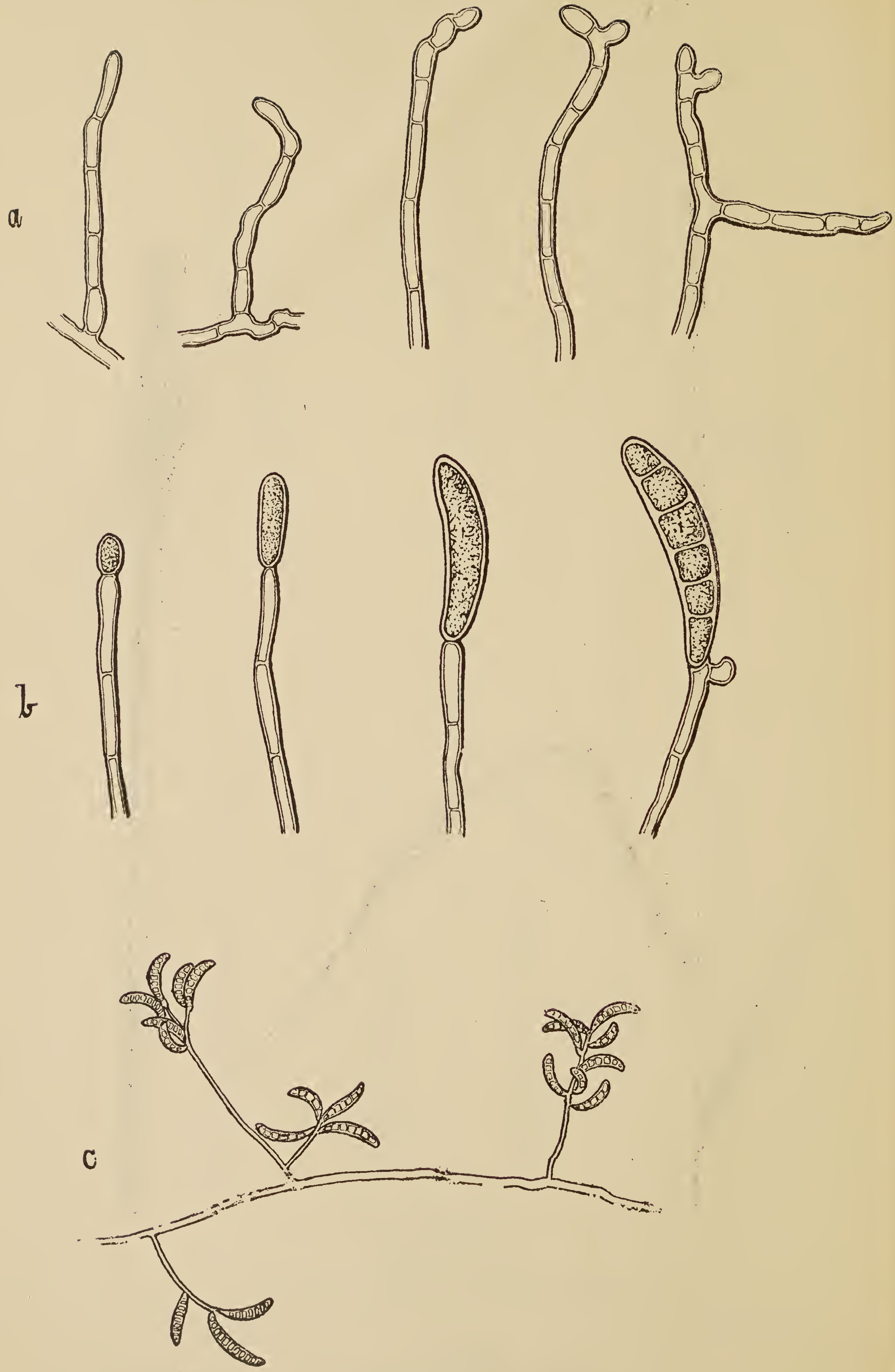


Fig. 2-A.
Helminthosporium spores.

See page 17.

Helminthosporium oryzæ.

Tamil—Pulli noi.
Telugu—Matsa tegulu.
Malayalam—Pulli rogam.

The disease is characterized by small brown linear spots occurring on leaves and may under favourable conditions cause the blackening of the nodes, neck and grains. The earheads are sometimes affected and they fail to emerge from the sheath. Individual grains are often attacked and such grains become either partially or totally lost. The existence of the disease was first brought to the notice of this department in 1918–19 when the paddy fields in the deltaic regions of Godavari and Kistna were affected and a heavy damage to the crop was reported. Investigation showed that the disease was present on a crop which was in a very weakened condition due to a variety of other causes.

The fungus spreads through spores which are borne on the leaves, stalk and grains. The fungus is also able to live as dormant mycelium in the seed and is carried from season to season. Seedlings raised from infected grains are often subject to a ' seedling blight.' The dead seedlings form the medium for the saprophytic development of the fungus and the spores blown about in the wind serve as secondary source of infection.

Control.—Fortunately the fungus is not a virulent parasite and attacks only plants which are weakened from other causes. The chief method of control lies in good farming. General sanitary practices such as destruction of infected stubble, clean cultivation, disinfection of seed and the importation of seed from non-infected localities go a good way in preventing epidemic outbreaks.

It is known to occur in all the paddy growing tracts.

Sclerotial disease—Sclerotium oryzæ.

This disease is one of the minor diseases of paddy and is caused by a fungus called *Sclerotium oryzæ.* It has been noticed only in a few of the paddy-growing areas of this presidency and is not known to cause any appreciable damage to the crop. The disease escapes the notice of the ryots in its early stages when the infected plants can be differentiated from the healthy ones by the peculiar phenomenon of ' tillering, ' i.e., the development of fresh green shoots at the base of the infected culms. Infected culms turn yellow and die. Grains are poorly developed and the glumes are in most cases empty. In many of the localities where the disease has been noticed the disease appears late in the season when the crop approaches maturity.

The disease develops mostly in water-logged localities and is rather rare in well-drained fields.

The sclerotia of the fungus are capable of living in the soil for several years but the question of the application of chemicals aimed at killing them is out of consideration in the case of a crop like paddy.

A sure and permanent method of controlling the disease lies in the breeding of disease-resistant varieties. The following general preventive measures based on general sanitary principles are recommended:—

(1) As soon as the disease is detected in the fields remove the infected plants and burn them.

(2) Do not plant too thick, but allow plenty of æration.

(3) Do not carry straw from infected fields to uninfected ones.

False smut of paddy—Ustilaginoidea virens.

Tamil—Nel pazham.
Telugu—Vari pandu.
Malayalam—Lakshmi.

The disease affects the earheads. The grains are not formed but swollen masses of fungus tissue fill in the cavities between the glumes. The young ovary is invaded by the fungus at an early stage in its development and is transformed into a hard mass. The life history of the fungus is still under investigation.

It is known to occur throughout the presidency, especially in the Northern Circars, Malabar, Tanjore and Tinnevelly.

Ephelis oryzæ.

Tamil—Nel kariputtai.
Telugu—Katuka tegulu.

This is an insignificant disease and mention is made of this simply because it has been recorded twice at Coimbatore. The earhead instead of being a loose panicle consisting of healthy well-filled grains becomes converted into a dark, solid, compact, cylindrical spike without the formation of grains. The disease has not assumed serious dimensions so far. It is advisable to remove the infected plants and burn them.

It is known to occur in Coimbatore, Trichinopoly, South Kanara, Coorg and Kurnool.

Paddy—Foot-rot.

Tamil—Thoor azhukal noi.
Telugu—Adugu kullu tegulu.

This disease is caused by a fungus (Cephalosporium) Fusarium sp. and has been noticed first on the Agricultural Research Station, Maruteru, and later at Coimbatore.

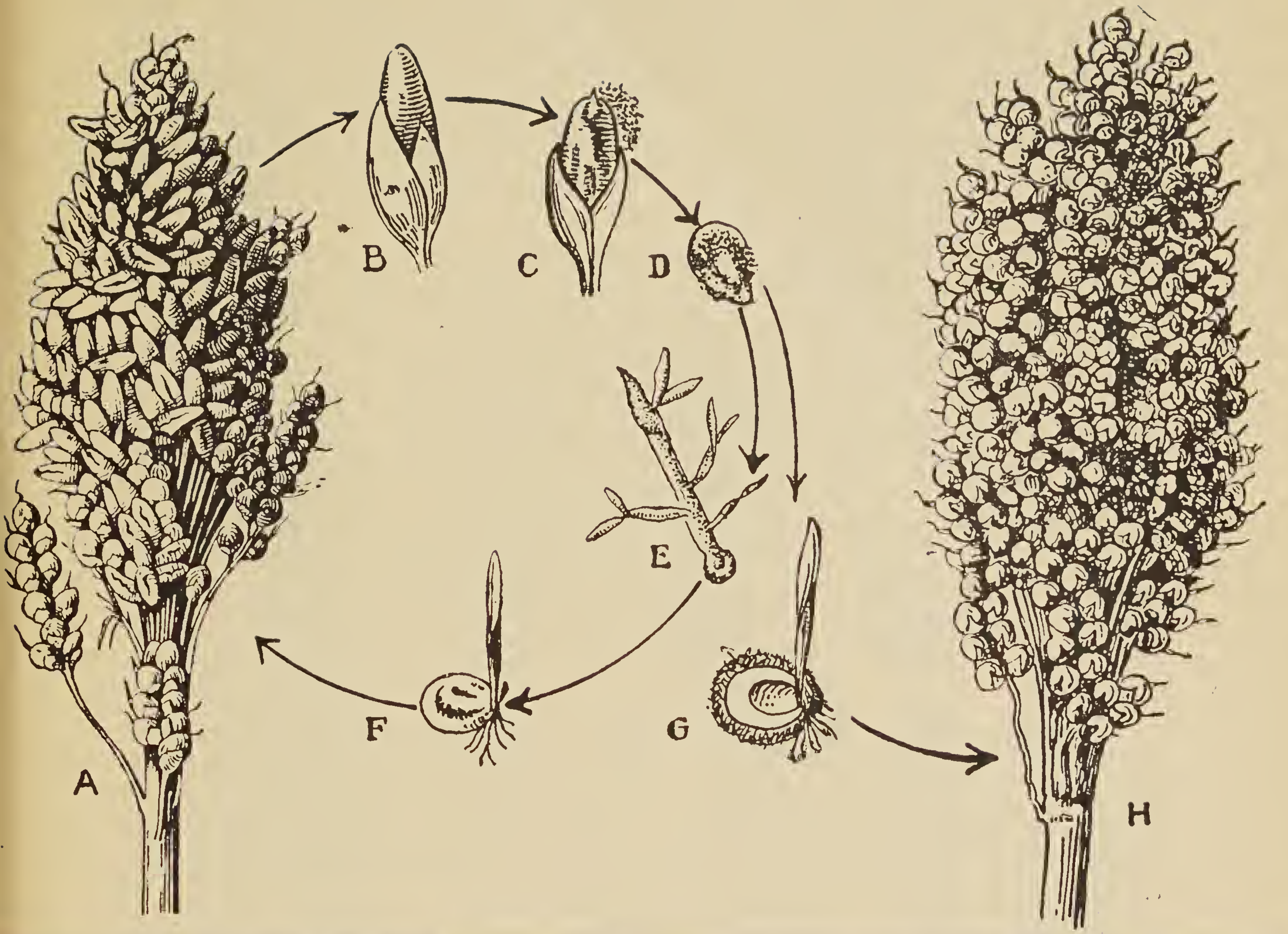
When the disease attacks the seedlings, the damage is very great. The disease causes paling of the leaves, elongation of the stalk and in course of time the entire seedling dies.

In the transplanted crop, the damage is not as great as in the nurseries. The elongation of the stalks is the chief symptom and adventitious roots spring in large numbers from the lower nodes.

No earheads are formed as a rule. A few that are formed are chaffy.

Steeping the seed after first soaking them in water in 2 per cent copper sulphate solution for about 15 minutes before sowing has been found effective.

It occurs in the wet lands of the Godavari and Coimbatore districts.



Life cycle of the Cholam Smut Fungus.

A. Smutted head. B. A smutted grain transformed into a spore sac. C. Spore sac broken open shedding the black powder (spores). D. Seed of cholam showing spores adhering. E. Germinated spore. F. Germinated spores attacking the seedling. G. Seed dusted with sulphur. H. Healthy head. (After Bombay Department of Agriculture, Leaflet No. 13 of 1919.)

CHOLAM.*

Cholam is subject to a number of fungoid diseases, the most important in South India being the smuts, the rusts and the leaf shredding disease.

Short smut on cholam—Sphacelotheca Sorghi.

Tamil—Kari puttai noi.
Telugu—Katuka tegulu.

This is one of the most important of the cholam diseases causing enormous losses to the cultivator every year. The losses can be avoided since the disease is easily preventible.

The smut appears on the ears of the plants when they are ripening, but the fungus which causes it has been insidiously working its way through the plant from the time the seed was sown in the soil. No difference between a healthy and a diseased plant however can be seen till the flowering period. In the diseased plants the individual grains in the ear instead of ripening into normal cholam seeds become filled with a black powder. The affected grain grows larger than the normal healthy grains, usually about twice its size. The smutted grain is covered with a light brown skin. The number of diseased grains in a panicle varies considerably. In some cases only a few grains are affected while in others nearly three-fourths of the grains in the panicle may be affected.

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* *Andropogon Sorghum.*

The smutted grains after a time ripen and the skin enveloping them bursts open liberating the black powder within. This black powder consists of millions of tiny spores of the fungus. These spores blown by the wind get lodged on the healthy grain and the process of harvesting, threshing and winnowing considerably help their spread. They rest on the healthy grains till such time the seeds are sown when they germinate along with the cholam grain and entering the plant the fungus continues to grow along with the cholam. When the cholam puts forth its earheads the fungus also produces masses of spores. Thus the life history of the fungus is closely linked with that of the cholam plant. The fungus robs the nourishment from the growing cholam plant and the spores are produced at the expense of the formation of healthy grains. The damage it can cause is therefore enormous.

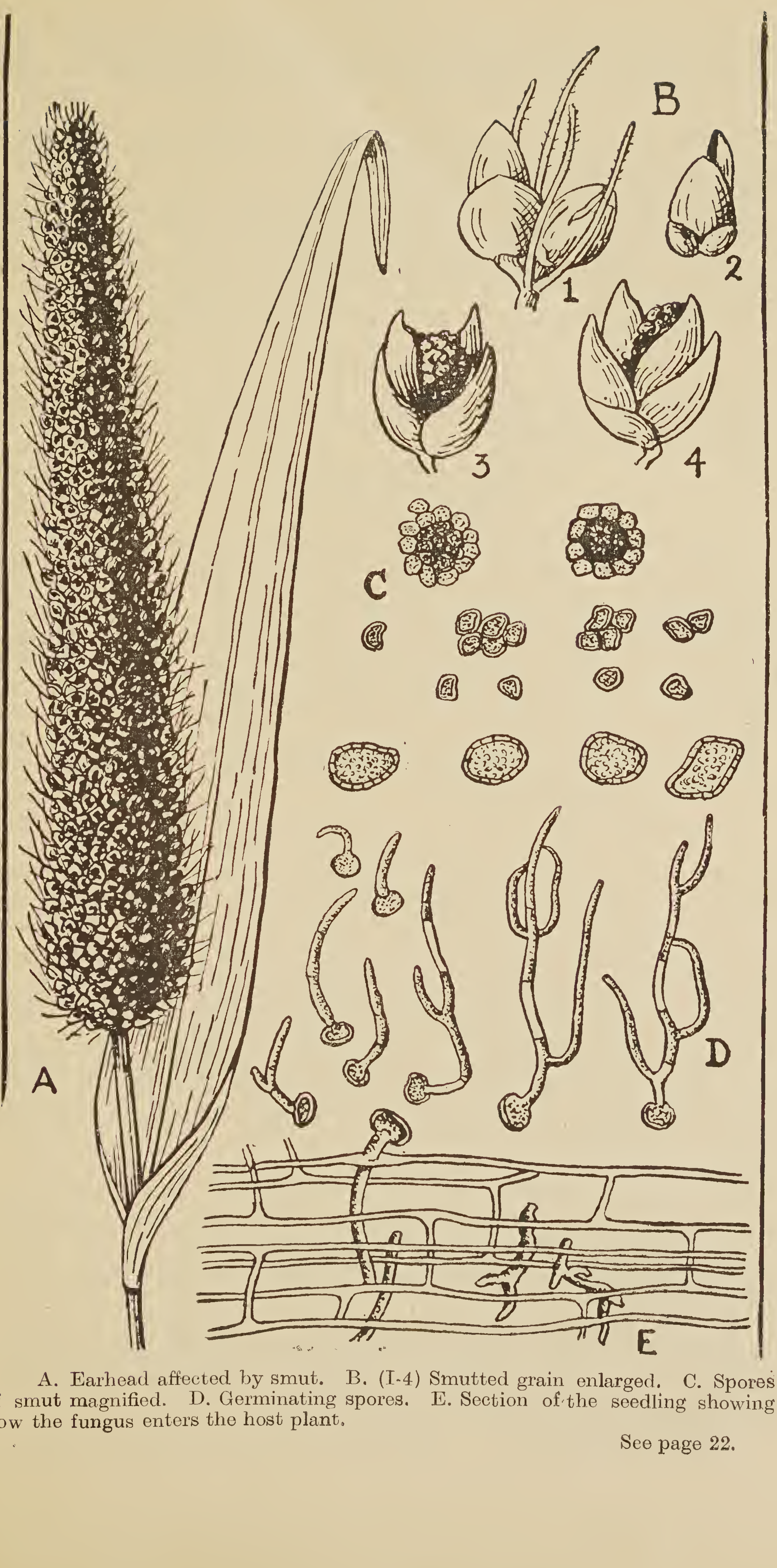
Control.—As the disease is carried over from one season to another by means of seed on which the spores of the fungus lodge seed treatment is indicated as a remedy. By steeping the cholam seed in a fungicide which will destroy the fungus without detriment to the cholam seed the disease is easily prevented. Copper sulphate solution (2 per cent) answers this purpose excellently.

To prepare 2 per cent copper sulphate solution the copper sulphate is well powdered and dissolved in water in the proportion of 1 tola (1 rupee weight) of blue stone for every pint of water (kerosene bottle). The solution is made in a wooden, copper or earthenware vessel. The cholam seed should be steeped in the solution for 15 to 30 minutes, care being taken to see that all seeds are thoroughly wetted. Seeds found floating may be skimmed off and thrown away as they seldom germinate. After steeping the seed is taken out and dried in the sun before it is sown. It should not be forgotten that the drying floor should be free from contamination of smut spores lest they should reinfect the seed. As a precautionary measure it is wise to wash the floor with copper sulphate solution beforehand.

Sulphur treatment.—In places where fine sulphur (200 mesh) is available it is cheaper and more advantageous to treat the seeds with this than with copper sulphate. The advantages of this treatment are that the seeds can be treated dry and if the seeds are not required for immediate use, can be stored without drying.

The efficacy of the treatment however depends on the thoroughness with which the seeds are mixed with the finely powdered sulphur. Any metal container with a tightly fitting lid and having a holding capacity of about four times the quantity of seed to be dusted can be used to treat the seeds.

Four to five ounces (10 to 12½ tolas) are sufficient for treating 60 lb. of seed. The seed should be treated in lots depending upon the size of the container, the required quantity of sulphur added and the container vigorously rolled for about five minutes. The seed is then



A. Earhead affected by smut. B. (I-4) Smutted grain enlarged. C. Spores of smut magnified. D. Germinating spores. E. Section of the seedling showing how the fungus enters the host plant.

See page 22.

ready for sowing or for storing if not required for immediate use. The cost of treating 7 lb. seed works at one pie and the cost of treating seed required for one acre works at about two pies.

It occurs in the Northern Circars, Ceded districts, Salem, Coimbatore, Madura, Ramnad and Tinnevelly.

Tenai (*Setaria italica*) suffers from a smut known as *Ustilago Crameri.* The life history of this smut is similar to that of short smut of cholam. The seed treatment recommended for short smut of cholam is equally effective in the case of Tenai smut also.

The disease occurs in the Bellary and Kurnool districts.

SUGARCANE.*

Red-rot (*Colletotrichum falcatum*) is the most serious disease to which sugarcane is subject.

Tamil—Sembulli pulippu noi.
Telugu—Erra kullu tegulu.
Malayalam—Sembulli rogam.

Symptoms.†—The first external symptom is that the upper leaves of a shoot usually one approaching maturity begin to lose colour and droop slightly. Then they wither at the tip and the withering progresses down the margin leaving the centre green. It is usually not the young leaves at the top of the shoot that are first affected but the third or fourth from the top, these being the most prominent leaves of the cane. Later on, the whole crop withers and droops. At this stage the plant presents an appearance of suffering due to extreme drought. In thick canes when one cane shows the symptoms the entire stool becomes ultimately affected. In course of time the entire stool withers and finally dies.

On splitting open a cane in the early stages of the disease a sour or acid smell is noticed and the tissues are found to be reddened in one or a few internodes usually towards the base. This discolouration which is often present long before there are any external symptoms, is at first confined to the vascular bundles but ultimately extends to the pith. The important characteristic of the disease, however, is that the red discolouration is not evenly distributed but streaks or patches of dark colour separate the lighter areas and red blotches with white centre transversely elongated are invariably found.

As the disease progresses, the pith gradually dries up and changes to earthy or brown colour. As a result, the rind folds in longitudinal depressions and the cane becomes very light and easily bent or broken. These are hollowed in the middle and often filled with a fluff of greyish mycelium.

The fungus invades the stem tissue and spreads rapidly. The reddening found in the cane is the result of fungus penetration. Mass of mycelium soon fills in the entire cane and the nutrition intended for the cane plant is used up by the fungus resulting in the utter failure of the crop.

The fungus fructifies usually after the cane dries up, the spores being formed in dark clusters externally just near the nodes. These clusters rupture the rind and are exposed to the air and the spores are spread from one place to another by wind.

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* *Saccharum officinarum.*

† E. J. Butler : Fungi and Diseases in Plants.

A previously sound cane can be infected only through wounds which expose the pith and through adventitious roots or young shoots and probably through eyes.

Control.—The disease assumes dangerous proportions in ill-drained areas and hence the first step in the eradication of this disease is the improvement of drainage facilities in a field. The next step is to plant disease-free setts as the disease is mostly spread through planting diseased setts. To make sure that only healthy setts are planted, it is necessary to examine the cut ends of the setts carefully. Any sign of reddening at the cut ends indicates the presence of the fungus and such setts should be discarded. Not only the particular setts alone but the entire clump with all the canes in it should be avoided, for, as was already discussed, when one cane is affected all the canes in the stool are likely to be affected. It is also necessary to disinfect the knife every time after cutting a diseased cane since the fungus may be transferred to the healthy setts. For this, the knife may be passed through a flame once or twice or dipped in 3 per cent copper sulphate solution.

The cut end of healthy setts may be dipped in 1 per cent Bordeaux mixture before planting.

Red-rot is a very serious disease and well-nigh threatened the sugarcane industry in the Godavari delta two decades ago. Careful sett selection and the rejection of susceptible varieties and growing resistant varieties re-established the cultivation of this very important crop in the deltaic tracts.

It occurs in the Northern Circars, Bellary, North Arcot, South Arcot, Salem, Coimbatore, Tanjore and South Kanara.

Smut (*Ustilago sacchari*).

Tamil—Kari puttai noi.
Telugu—Katuka tegulu.

The disease is easily recognized in a field. Affected plants are distinguished by the formation of a long whip-like dusty black shoot from the growing shoot. The leaves do not open out but become converted into a long whip-like structure consisting of masses of black spores covered by a white thin papery covering. After a time, the white covering ruptures, exposing the spores inside. The spores are blown about by the wind and healthy plants are infected.

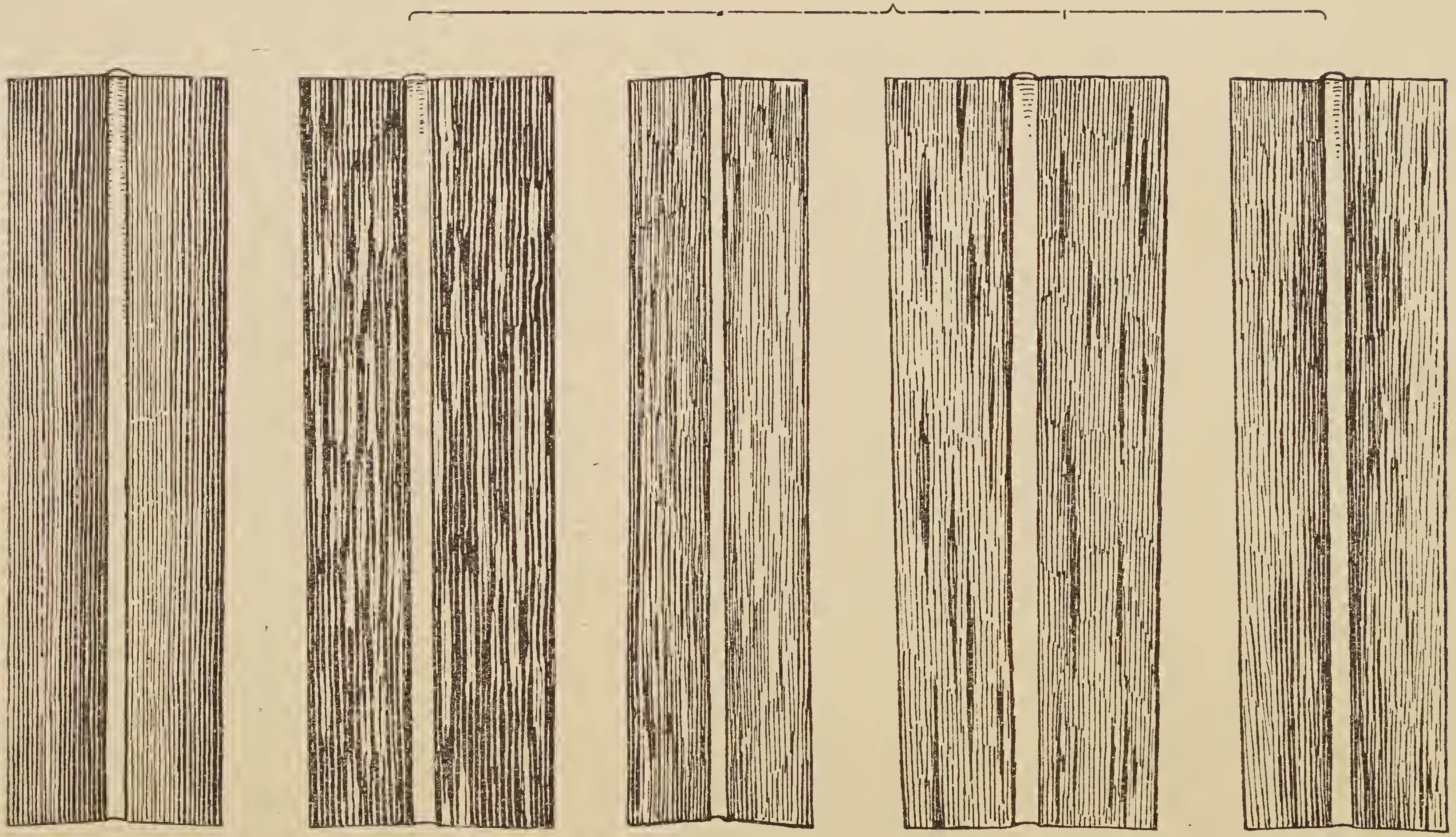
The fungus grows within the plant for a period and then affects the shoots when in the place of the growing spindle a long whip-like structure is formed.

Remedy.—Since infection takes place in the air through young shoots or eye-buds or a wound on the stem, seed treatment will not prevent the disease. A smutted plant can never recover but acts as source of infection to other healthy plants. Prompt removal and burning of the affected clumps are essential.

It occurs in the Northern Circars, Coimbatore and South Arcot.

Healthy.

Diseased.



Vellai.

Col.

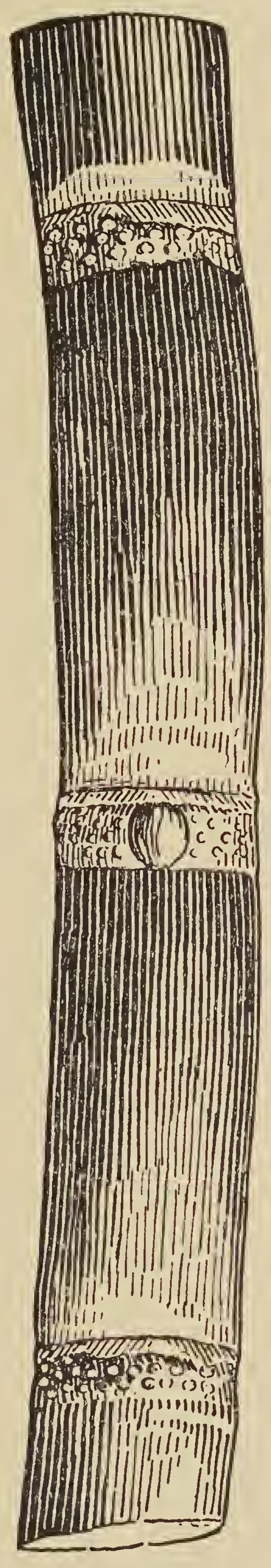
Java Hebbal.

Poovan.

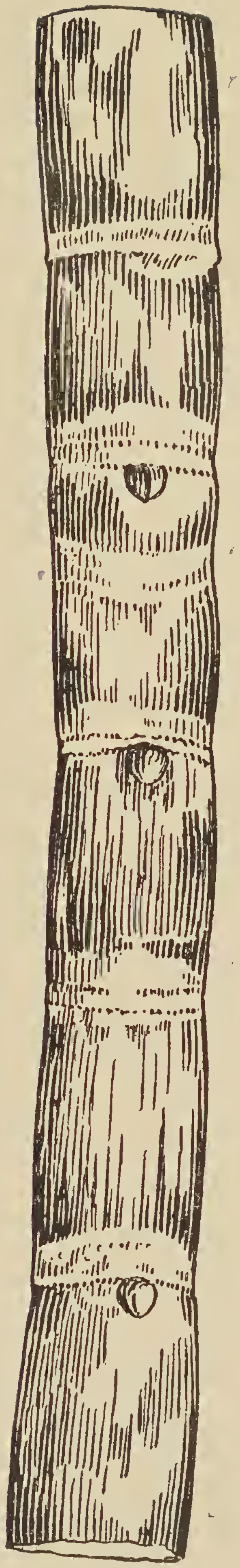
Sugarcane Mosaic.

See page 26.

Sugarcane Mosaic.



Healthy stem.



Diseased stem.

See page 26

MOSAIC DISEASE.

Tamil—Temal noi.
Telugu—Matsa tegulu.
Malayalam—Pandu rogam.

Mosaic.—The disease which is one of the most dangerous of all sugarcane diseases has not as yet made itself felt as a serious menace in South India, but its presence in the sugarcane areas in the presidency indicates the possibilities of the danger ahead and the potentialities of very great damage. Historically the discovery of the disease dates back to 1896 but definite progress in the knowledge of the disease is of very recent times. It was recorded in 1913 in Queensland but only during the last decade the problem has been studied in great detail.

Symptoms.—As the name implies the disease is characterized by a peculiar mottling of the leaves. From a distance a badly diseased field shows a yellowish instead of the healthy dark brown colour. On close examination the discolouration is found to be due to innumerable whitish or at times yellowish blotches on the leaf surface (vide plate). These blotches are elongated and possess wavy margins. The pale areas alternating with the normal green form a distinctive pattern, the details of which vary with the variety of cane and at times in different specimens of the same variety (vide plate). For instance in Java—Hebbal and Vellai the normal dark green colour appears as a few irregular islands on a pale green back ground. On the other hand in the varieties Poovan and Co. 1 the green colour forms a back ground for irregular white blotches. As a rule the disease is found on the leaves. In some cases the mottling tends to become obscured with the age of the leaf so that it is difficult to detect it in the older leaves. The symptoms of the disease are therefore unmistakably found on the youngest leaves of the shoot and they are invariably visible as soon as the leaves unfold. In some varieties of cane a kind of mottled appearance caused by other causes than the mosaic disease is found confined to the old lower leaves, while the young leaves are quite free so that one has to depend on the examination of the spindle to satisfy oneself that it is not a case of mosaic. The disease is also to be differentiated from entire chlorosis of the leaves where the whole leaf turns white or yellow and from partial chlorosis where yellow stripes run along the whole length of the leaf.

Causes of the disease.—Our knowledge of the exact cause of the disease is at present very incomplete. All attempts to isolate a causative organism have so far failed. But all the available evidence goes to prove that the disease is caused by a 'virus,' that is an ultra-microscopic substance which is infective, and can be transferred from a diseased plant to a healthy plant by artificial methods. The point to be noted is that the disease is *not* caused by a fungus.

Effects of the disease.—This disease does not kill the cane. In advanced cases of infection, the stem gets shrunk and the rind cracks. In other countries where the disease has been in existence for several years material reductions in the output of cane and sugar occur. The loss in Porto Rico has been estimated to be about 40 per cent while in Hawaii and Trinidad it has varied from 3 to 50 per cent.

How the disease spreads.—The disease is spread through (1) diseased setts and (2) the agency of a sucking insect—

(1) Since the mosaic virus is distributed in a diseased plant throughout its system, i.e., stem, leaves, roots, etc., it is essential to

plant setts taken from plants free from the disease. Planting diseased setts invariably gives rise to diseased plants. By this means the disease is easily spread over large areas.

(2) The insect agency is capable of transmitting the disease from a diseased plant to a healthy plant. So far as is known at present this is the only means by which new plants get infected. Since however the disease can be carried over only short distances the danger is not very great.

Control measures.—The disease is incurable. It occurs under all conditions of soil, climate, cultivation and manuring. Diseased plants have been found to respond to heavy manuring, but they are never known to equal healthy canes similarly treated. The only alternative, therefore, lies in preventing the spread of the disease and this can be done by the following means:—

(1) The use of setts from mosaic free clumps for planting.

(2) Systematic weeding out affected stools from the field as soon as stray cases of disease are noticed.

To secure the maximum success the following measures are recommended:—

(1) Setts for planting should be obtained from a locality where the disease is absent. If this is not possible they should be obtained from selected disease free stools. The selection should always be done before the leaves are cut. Any stool showing mosaic symptoms on the leaves should be discarded.

(2) After planting, the seedlings should be systematically and periodically examined and in case any affected stools are noticed they should be immediately destroyed in order to prevent the spread of the disease through insects. The disease spreads rapidly only during the period when the cane is growing vigorously, i.e., the first five months after planting and hence special care should be taken during the period to remove diseased plants. Whenever a field of cane is seriously infested with disease the whole crop should be cut and milled and none of the canes, used for seed. The field should then be cleared of all diseased material such as ratoons from old stools and weeds. When this operation is done thoroughly the land can be utilized for replanting, but whenever possible a rotation of crops should be practised to ensure security against re-infection.

The disease occurs in Godavari, South Arcot, Coimbatore, North Arcot, Chittoor, Chingleput, Trichinopoly and Malabar districts.

Pine apple disease (Thielaviopsis paradoxa).

As the name indicates the disease is characterized by the affected canes emitting a peculiar odour resembling that of a ripe pine apple. The stem of affected canes becomes hollowed out and sooty encrustation of the spores of the fungus fills in the space.

The fungus is a wound parasite and enters through the cut ends of setts at the time of planting. It spreads within the plant and causes enormous damage to the growing seedlings. Occasionally older plants are attacked.

Dipping the cut ends of setts in Bordeaux mixture may protect the plants from the disease.

CHAPTER V.

FRUIT TREES.

MANGO.

Mildew—Oidium Sp.

Tamil—Sambal noi.
Telugu—Budithe tegulu.

The disease appears at first as white patches on the surface of flower-stalks, flowers and fruits. These patches enlarge and ultimately the entire inflorescence (flower head) is invaded. The flowers dry up, fruits fail to set. In bad seasons, the disease causes much damage.

Remedial measures.—Dusting with finely ground sulphur (passing through 200 mesh sieve) has been found to be very effective in preventing the disease. Spraying with Bordeaux mixture before the flowers open also controls the disease to a limited extent.

Sooty mould (*Capnodium*).—The fungus spreads on the surfaces of the leaves forming, as it were, a black veil, which cuts off light from the green leaves. The fungus is not directly parasitic on the mango plant, since it feeds entirely on the secretions of the insects (aphids and scale insects) with which it is always associated, but may cause slight damage to the leaves and may impair their assimilating and respiratory functions.

Bordeaux mixture with the addition of an insecticide like fish oil soap will keep the disease in check. The disease is seldom serious.

Brown leaf-spot (*Glœosporium sp.*).—Young leaves are attacked. The fungus causes brown spots which are small at first, but become gradually large irregular patches.

The disease causes damage mostly in the nurseries of grafts.

Spraying with weak ½ per cent Bordeaux mixture is effective in preventing the disease.

Pink disease—Same as in cashewnut.

Grape-vine—Powdery mildew.

Tamil—Sambal noi.
Telugu—Budithe tegulu.

Powdery mildew is caused by the fungus *Uncinula necatar.* This disease is one of the worst enemies of the grape-vine grower. It attacks all green parts of the vine, leaves, stems, flowers and fruit and the damage it can cause is very great. The disease appears at first on the leaves as white patches on both the surfaces. These patches grow in size and if left unchecked may cover the entire surface of the foliage. When the shoots are attacked, they usually turn black and present a blasted appearance. When the flowers are involved they fail to set fruit and dry up. The fungus spreads on young and half grown berries. In the former case the berries drop off while in the latter the berries usually crack and their development is arrested. In bad cases, all the berries are covered with a thick coating of powdery white stuff—the spores of the fungus. Ripe berries are not usually attacked by the mildew.

The fungus spreads on the surface of the green parts of the grape vine plant and by sending the feeding organs (haustoria) into the tissues of the host plant, robs it of a greater part of its nutritive material. It spreads from plant to plant by means of spores which are carried by wind. They germinate under favourable conditions giving rise to a growth of mycelium.

The vine is liable to the attack of the fungus just when it is putting forth new shoots after pruning.

Treatment.—Bordeaux mixture (1 per cent) has been found effective in controlling the disease. Sulphur dusting has proved to be very efficacious in the Bombay Presidency in checking the disease (Bulletin No. 168 of 1930, Bombay Agricultural Department).

Downy mildew of grapes is caused by the fungus *Plasmopara viticola Berl.* The fungus affects the young stems, leaves and fruits penetrating all the tissues except the wood. The first sign of attack is the appearance of brown angular spots on the lower leaves, from the underside of which a delicate white downy mass develops. The spots may spread until the whole leaf is involved when it falls prematurely. The disease develops rapidly in wet weather (since it is spread by zoospores). The fungus may cause considerable damage to the vines (1) by reducing their vitality and (2) by affecting the fruits, which are rendered worthless.

Remedial measures.—Spraying with Bordeaux mixture controls the disease and has become a routine practice in vine growing countries.

Birds-eye disease (*Anthracnose*).—Caused by the fungus *Glœosporium ampelophagum.* All the green parts of the plant are attacked. The fungus causes the formation of spots, which are of the birds-eye type. The spots on the fruits are ashy brown in appearance, with a pale central core surrounded by a brown outer border a red purple ring usually separating the two. The unaffected portion of the berry is green.

Remedial measures.—Prompt removal of affected parts and repeated sprayings with Bordeaux mixture effectively control the disease. Spraying with lime sulphur is also efficacious.

FIG.

Rust—Uredo fici.

Tamil—Tāmra noi.
Telugu—Tamra tegulu.

The rust occurs on leaves and leaf-stalks forming brown patches on their surface characteristic of rust. In severe cases of attack the disease completely defoliates the plant.

Removal of affected leaves and spraying with iron sulphate solution ½ per cent and dusting with sulphur have been reported to be effective in checking the disease.

PLANTAIN.

Panama disease or Plantain Wilt caused by the fungus *Fusarium cubense*, is a disease of considerable notoriety since it almost destroyed the Banana industry in parts of Central and South America and Australia. Its presence in India has been noted in Bengal in earlier years, but in South India its presence has been noted comparatively recently. In the padugai lands of the Cauvery delta, the disease has been noted in isolated areas and the potential danger is indeed very great.

The fungus apparently lives in the soil and attacks the plant underground through the roots and rhizomes. The seat of the disease is the vascular system of the root stock, where the fungus invades the vessels and disintegrates the walls.

The external symptoms are the drying up of the leaves and the gradual wilting of the plant. At first the older leaves turn yellow from the margin or develop yellow spots and dry up. In course of time the younger leaves also follow suit, usually in order of age. The last leaf alone may stand erect and green for a long time. In some cases the leaves may droop and break down while still green. Often, the outer leaf sheaths also split. Bunches are rarely formed and when formed show signs of arrested development.

On cutting the pseudo-stem of a diseased plant at the base, the cut surface shows red, black or brown spots marking the portion of diseased vascular bundles. In a healthy stem the cut surface is a uniform white.

Drainage and climatic conditions play an important part in the spread of the disease, but once the disease is established eradication is well-nigh impossible. Susceptible varieties should not be grown in localities where the disease is prevalent. On no account should suckers obtained from a locality where the disease is prevalent be planted in new gardens. When an area has become heavily infected, it is advisable not to grow plantains for a number of years.

ORANGES—LIMES—CITRUS SP.

Mildew.

Tamil—Sambal noi.
Telugu—Buditha tegulu.

This is caused by an Oidium sp. This disease occurs on the leaves and young shoots as ashy white powdery coating. Sometimes young flowers and fruits are attacked. The flowers do not open properly, but shed in large numbers. The setting of fruits is thus prevented. The spores of this fungus are produced in large quantities and the disease spreads very rapidly by wind. The disease is prevented by spraying the young shoots and flower bunches before they begin to open, with Bordeaux mixture. Dusting with flowers of sulphur with equal parts of lime has also been found effective.

Sooty mould (*Capnodium*).—The leaves get covered by a dense black layer and this is made up of thick interwoven black hyphæ of fungus. There is a net work of this fungus covering the entire surface of the leaf. The disease occurs only after the plants are attacked by an insect and the fungus grows on the sweet honey-like juice which this insect produces. If the trees are kept free from insects this fungus cannot exist. This fungus causes injury by covering the leaf-surface with a black covering. Sunlight which is necessary for plant growth is obstructed and the breathing pores are closed and hence the plants cannot breathe. The destruction of this insect which is the source of food for this fungus should be aimed at to prevent this disease. This can be controlled by a spraying of fish-oil soap and tobacco decoction. This is prepared by dissolving one pound of fish-oil soap in ten gallons of water and adding one pint of good tobacco decoction.

Die-back or wither-tip disease.

Tamil—Sulli tattal.
Telugu—Pulla virugadam.

This disease is caused by the fungus *Colletotrichum glœosporiodies*. It shows itself at the tips of leaves. Young leaves get affected and prematurely fall off. The young branches lose their leaves and die back. They stand bare and brown resembling the branching horn of a stag or deer. If these dried twigs are examined with a lens black spots will be found. In these spots spores of the fungus are present.

How to prevent this die-back.—It is of the highest importance to prune or cut off these dead branches in dealing with this disease. Dead branches should be cut off and tar applied to the cut ends. It is very important in pruning to cut out not only the dead branches but also those that show signs of disease. The distance to which the disease has progressed can be seen by the presence of new shoots with a sickly yellow colour. Careless pruning makes matters worse. When pruning, care should be taken to make smooth cuts, usually at the base of a branch so as not to leave projecting bits, as fungus usually enters through them.

Great care should be taken after severe pruning of this kind. The garden should be sprayed with Bordeaux mixture so that the other healthy portions may be protected from the attack of this disease. It should be well manured so as to bring about a vigorous healthy growth and to render the trees resistant to the further attack of the fungus. Attention should be paid to proper drainage.

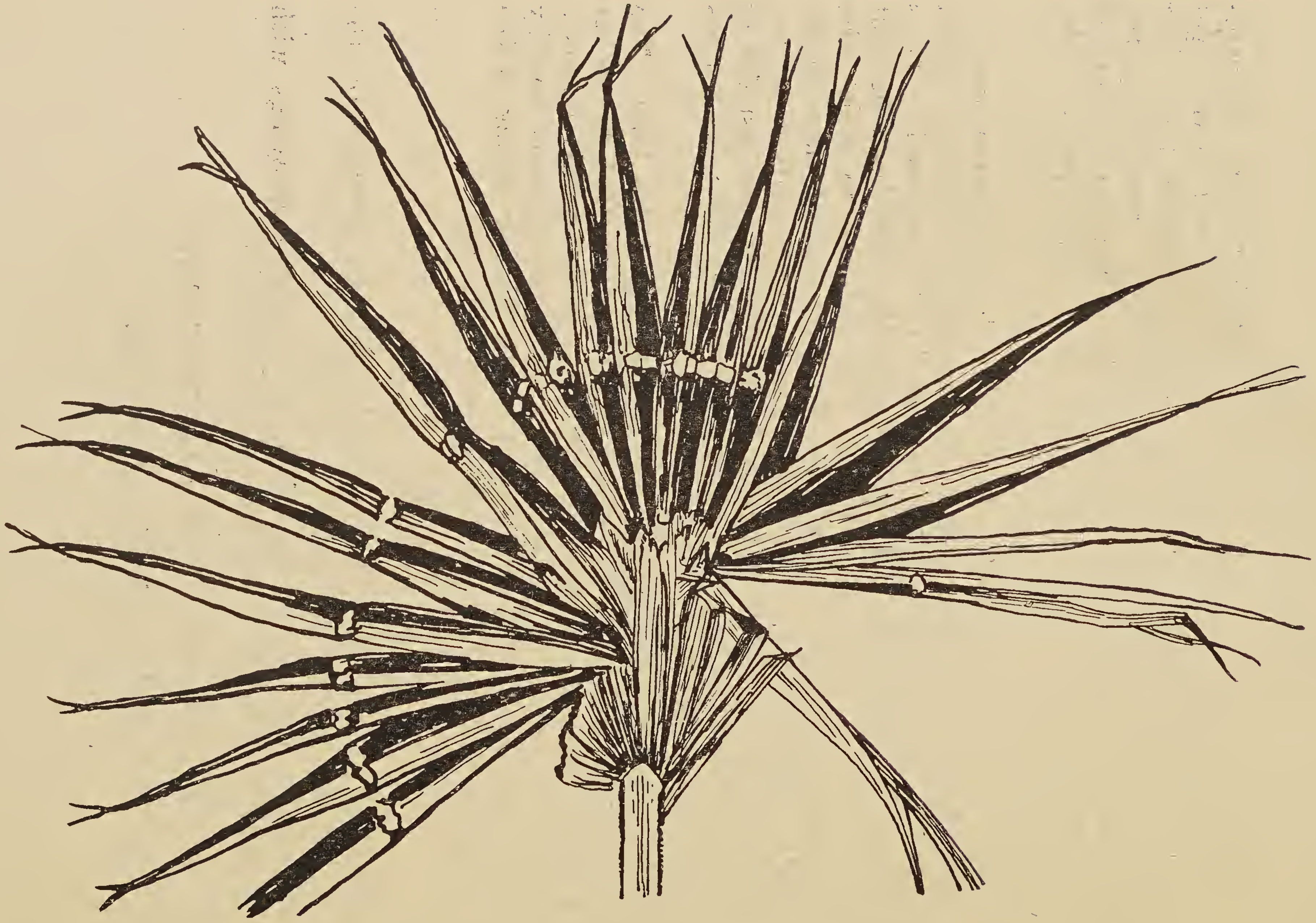
Scab.

This disease is characterized by raised warty out-growths on the surface of the leaves and the stem.

Pruning the badly affected branches and repeated sprayings with 1 per cent Bordeaux mixture has been found effective.

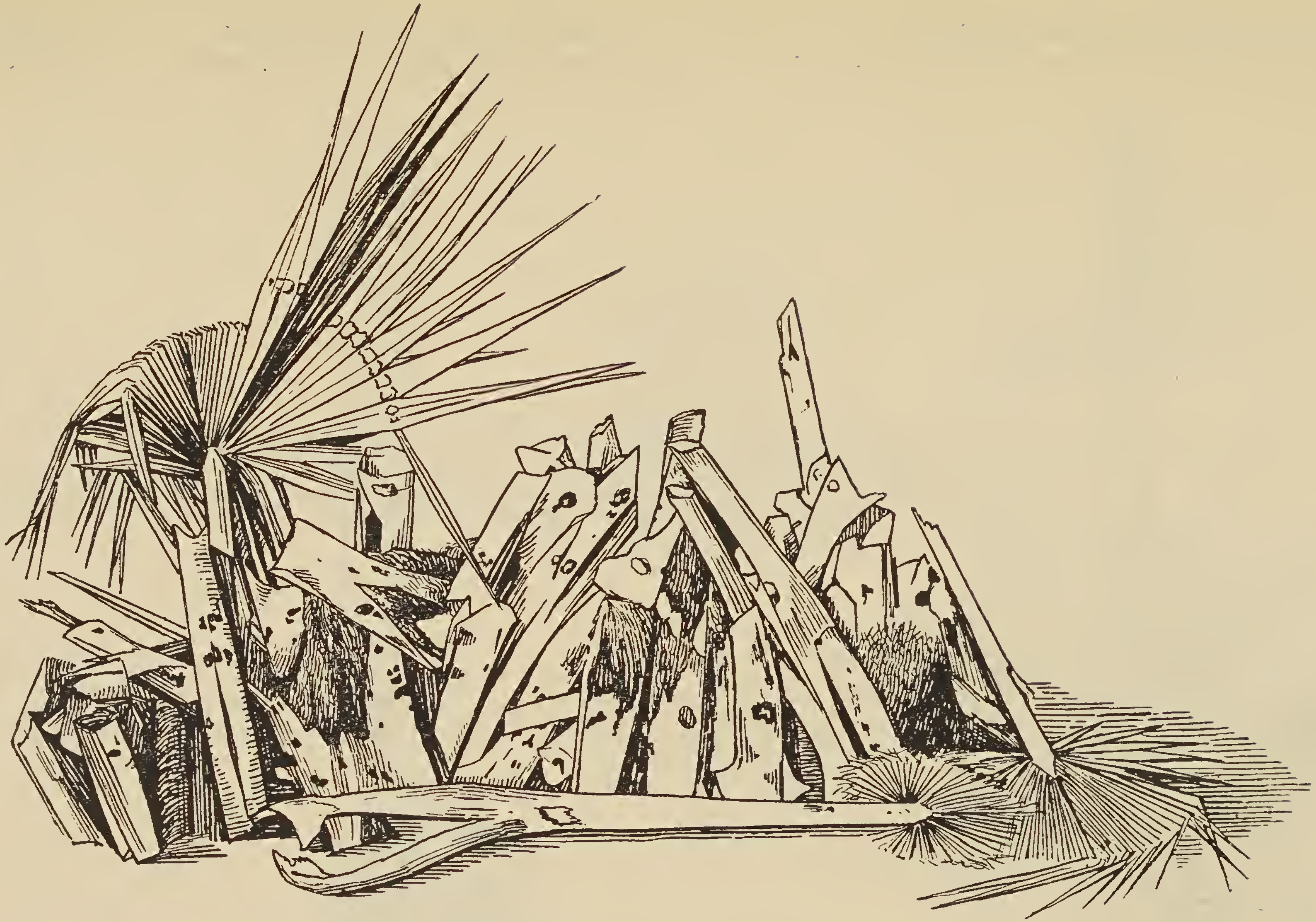
Pink disease (*Corticium salmonicolor*).

Vide Cashewnut (page 56).



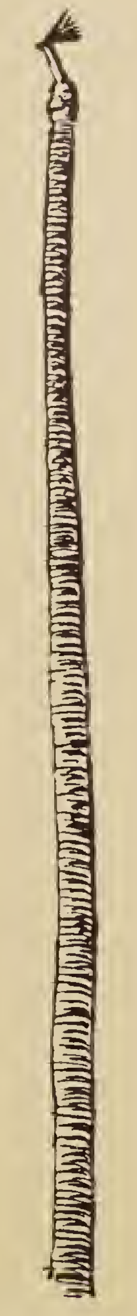
Diseased spots (light coloured) on the leaves.

See page 36.

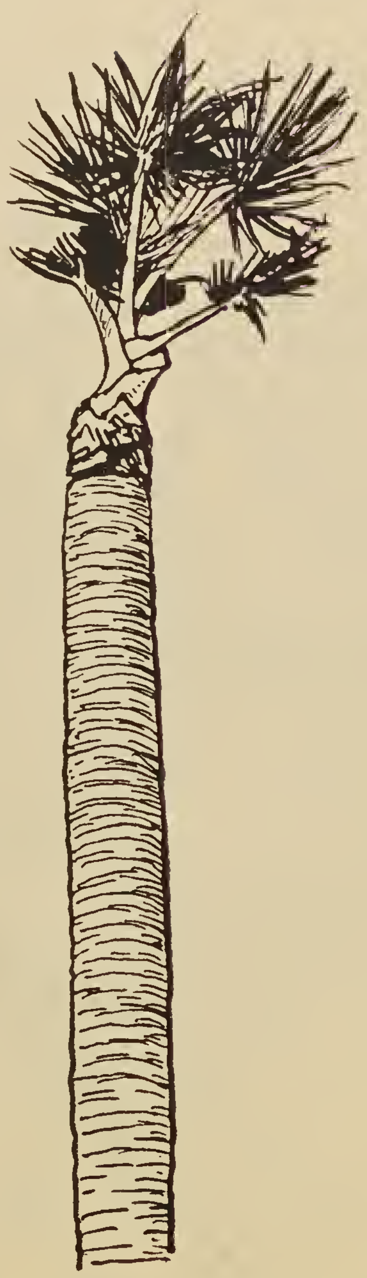


Leaf-bases and leaves with disease-spots to be burnt.
(Reproduced from the Agricultural Journal of India, Vol. VII, Part III.)

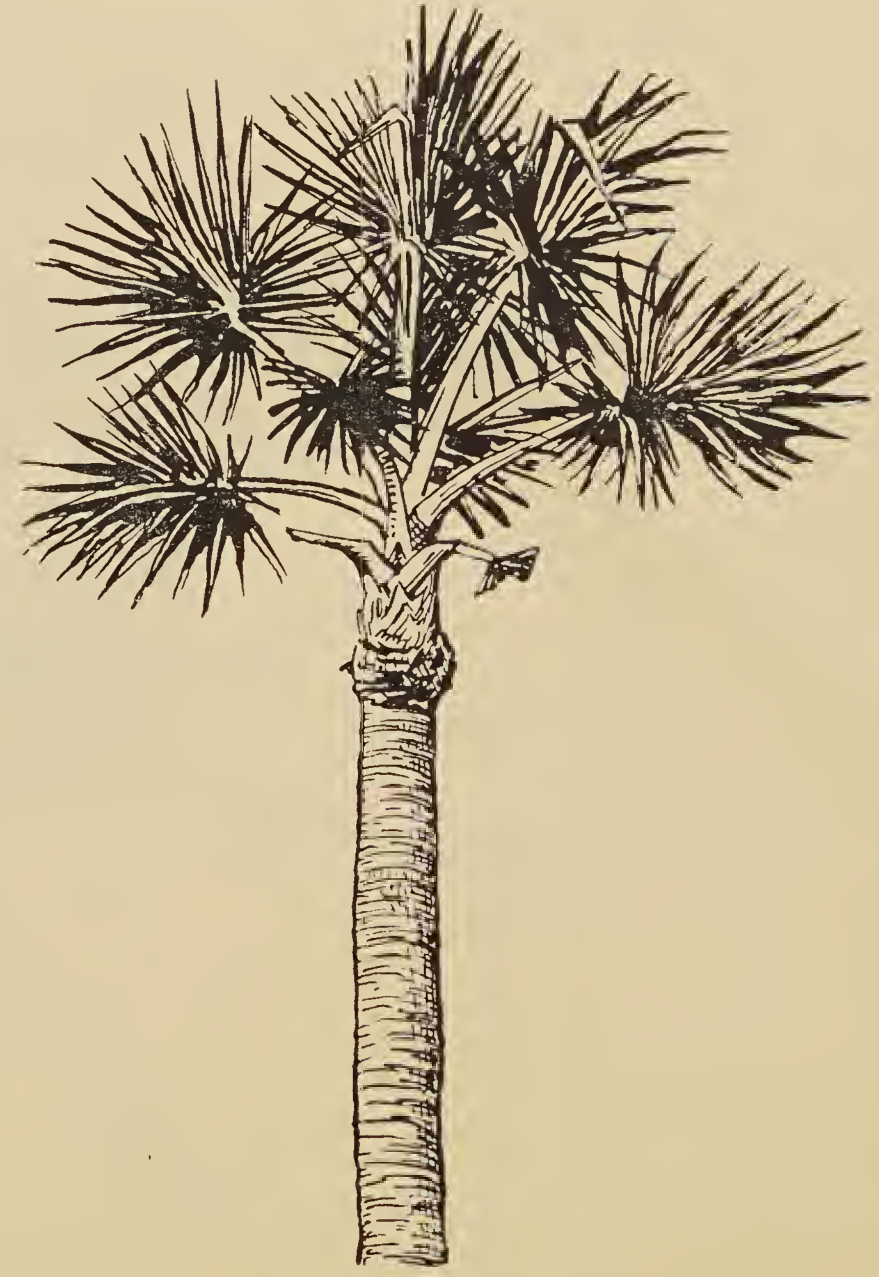
See page 36.



An outwardly infected tree that had been operated upon six weeks before.

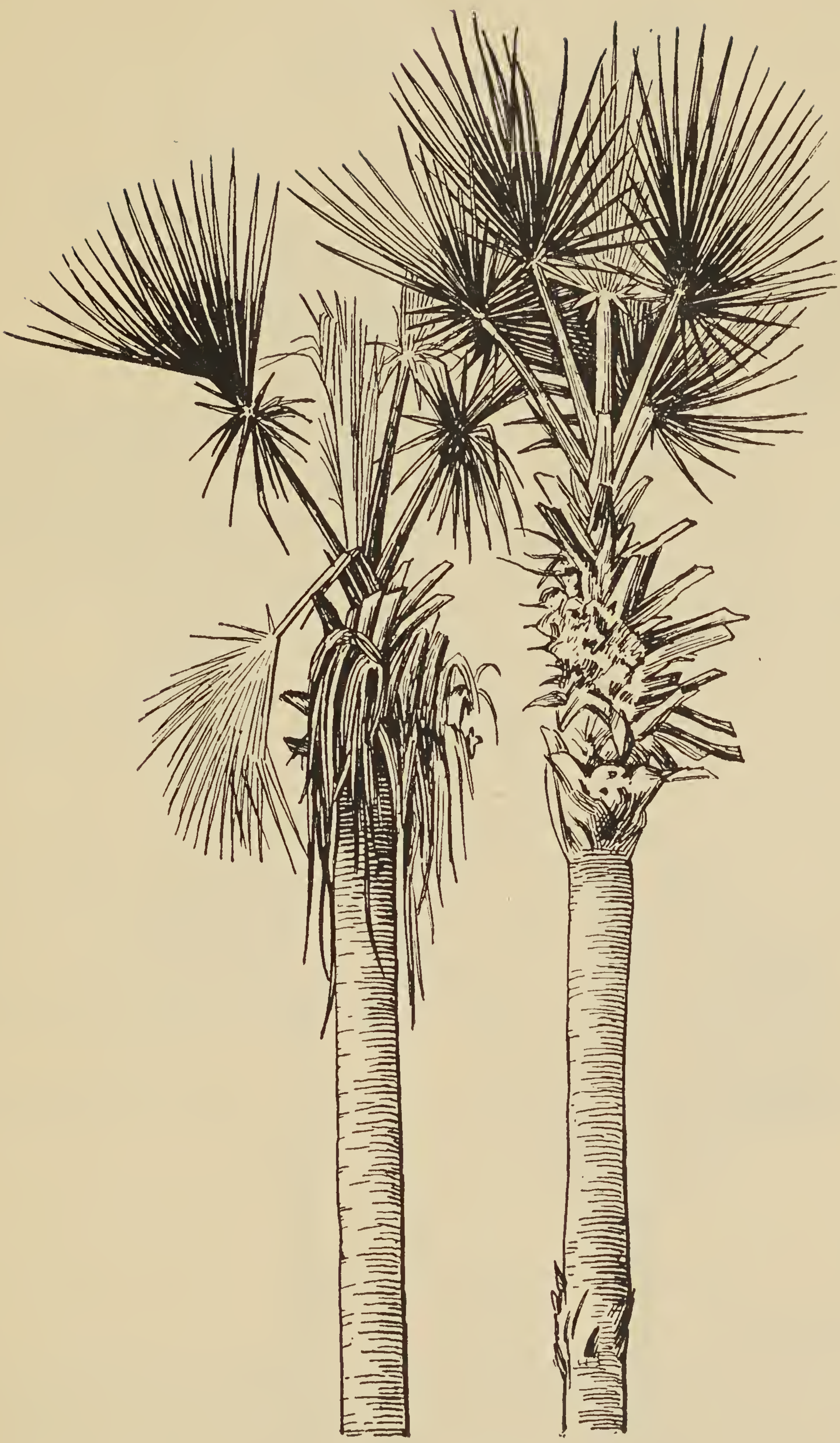


An outwardly infected tree that had been operated upon six months before.



An outwardly infected tree that had been operated upon two years before and is now full-sized.

See page 36.



Palmyra bud-rot.
Central shoot (light coloured) turns pale.

See page 36.

CHAPTER VI.

PALM DISEASES.

Palmyra (*Borassus flabelliformis*).

Bud-rot.

Tamil—Kuruthu azhukal noi.
Telugu—Movvu kullutegulu.
Malayalam—Koombu cheechal.

Bud-rot of palmyra palms is caused by a fungus *Phytophthora palmivora.* The first signs that a palmyra is diseased are (1) either the central expanding leaf turns yellow and dries up; or (2) rows of diseased spots are seen on the expanding leaves.

Soon after the death of the central leaf, the growing point at the base of the bud dies. Then soft rot sets in which causes the leaf tissue surrounding the growing point to become soft and rotten. Ultimately the expanded green leaves one by one wither and die and then fall off till at last nothing is left but a bare stem.

If the lower leaf sheaths of a diseased palmyra be cut off one by one brown spots varying in size are seen on the leaf blades, leaf sheaths and spathes. These spots are covered with a mass of mycelium and sporangia.

If the bud is not dead and the diseased spots are found on leaves the trees can be saved by cutting off the affected leaves and leaf sheaths leaving the healthy buds. Then the tree puts forth new leaves and grows to its natural size once again.

If the bud is dead the crown should be cut down and split into pieces and burnt to prevent the disease from spreading on to the other healthy trees.

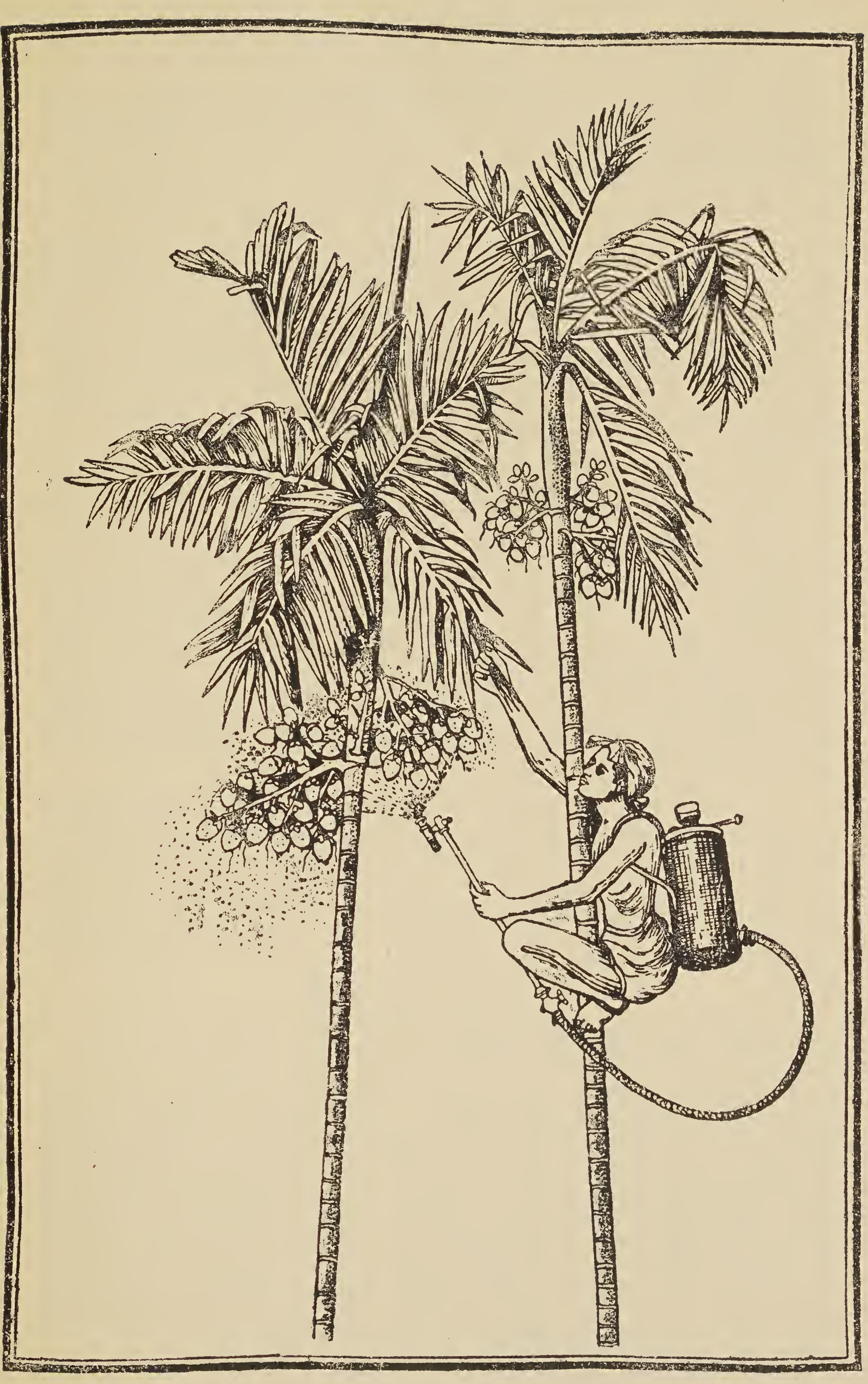
The disease occurs in Godavari, Kistna, Guntur and Malabar.

Arecanut (*Areca catechu*).

Fruit-rot.

Malayalam—Mahali.
Kanarese—Koleroga.

Fruit-rot and fruit-fall (Mahali disease).—This is caused by a fungus *Phytophthora omnivora Var. Arecæ.*—The arecanuts rot and fall off from the bunches. The surface is covered by a white mass of mycelium and sporangia. The loss is often considerable and sometimes the whole crop is lost. The disease comes on soon after the outbreak of the south-west monsoon and lasts till about September. During the rains the sporangia produce zoospores and these spread from tree to tree and from bunch to bunch in rain drops blown by wind. When they fall on healthy arecanuts they infect them and cause the fruits to rot.



Spraying against Mahali.

See page 36.

As the disease is carried over from season to season the old diseased bunches should be plucked before the monsoon sets in and burnt. The new bunches should be sprayed with Bordeaux mixture before the monsoon sets in. As the rains are heavy an adhesive substance (resin boiled with soda) is added to make the mixture stick well to the bunches of nuts.

This disease occurs in Malabar, South Kanara, Cochin and Mysore.

Foot-rot.—This disease of the arecanut palm causes the foot of the tree to rot and brings about the gradual death of the palm itself. In the early stages, the leaves gradually change from a bright green to a dull yellow colour and droop as if suffering from want of water. The crown shrinks in size and slowly dries up and eventually the palm succumbs. The core of the stem is soft and rotten up to a height of a foot from the ground. Palms under ten years are not affected. The disease is found to be distributed throughout the gardens.

Though the symptoms resemble those of water-shortage the supply of any amount of water will not enable the palms which are once affected to regain their original vigour. The disease is caused by a fungus called *Fomes lucidus.* It attacks the roots and base of the stem. Since the fungus blocks up the water conducting system of the palm, the passage of water to the crown is prevented and hence the symptoms of drought. At the base of the stem, in many cases, can be seen the bracket-shaped fructifications of the fungus, which develop during the later stages of the disease. These may be small or large and produce innumerable spores of seeds of the fungus. Sometimes these develop only on the stumps of the palms left in the ground after they have been felled.

The spread of the disease takes place both through the soil and through the air. Infection spreads through the soil by the roots of a diseased palm coming into contact with those of the neighbouring healthy ones. The innumerable spores that are produced in the fructifications of the fungus are blown about by the wind and these under favourable conditions produce further infection. This disease is found distributed throughout the gardens and not confined to any definite area.

This disease is known to occur in South Kanara and in the Malnad districts of the Mysore Province.

Remedial measures.—It is impossible to save a tree which has once been attacked by the fungus. The control measures should, therefore, be directed against the spread of infection to healthy trees. For this purpose, the affected trees should be completely isolated from the rest by a trench two feet deep and one foot broad dug all round it. The trench should be at least four feet away from the affected tree. In digging the trench, care should be taken to throw the soil removed towards the base of the infected tree to prevent infected soil coming in contact with healthy trees. The trench may be filled with lime, but in any case care should be taken that the trench is always kept open. The diseased tree should then be dug out taking care to remove that every bit of the diseased tree is removed and burnt on the spot.

The stem-bleeding disease.

Tamil—Sar ozhukal noi.
Telugu—Lakka uragadam.
Malayalam—Rakta kari roga.

This disease is in many respects similar in appearance to the stem-bleeding disease of the coconut palm. The disease starts at the base of the palm and gradually travels upwards. Both young and old palms are affected but the effects are considerably more severe in the young sappy palms than in the older woody ones. In the case of young palms, a discoloured depressed portion is noticed in the beginning and the portion gets cracked exhibiting the rotting black tissue within. As the disease advances the cracks widen and the fibrous tissue within gradually dries up and falls off leaving hollows of varying depths on the stem. The diseased tissue has the same appearance as in the case of the stem-bleeding disease of the coconut palm. Exudation of sap in the form of a brown liquid which dries up on the stem was noticed in some cases, but it does not appear to be a universal symptom. In old arecanut palms the crowns gradually become small in size and bearing ceases. But in young palms the injury is quicker and greater so that the palm may die as a result of the disease.

The disease is caused by a fungus known as *Thielaviopsis paradoxa.* A microscopic study of the organism shows that the fungus is identical with the one causing the ' stem-bleeding ' of coconuts, the ' Pine-apple disease ' of sugarcane and the ' soft-rot ' of pineapples. It has also been observed that the fungus cannot gain an entrance into the same hosts except through wounds. The above observation is noteworthy in that it points to the importance of avoiding wounds on the stems of arecanut and coconut palms. Any wound accidentally made should be immediately painted over with hot coal-tar, and this will prevent the entry of the fungus through such wounds.

This disease is known to occur in parts of Malabar and Coimbatore.

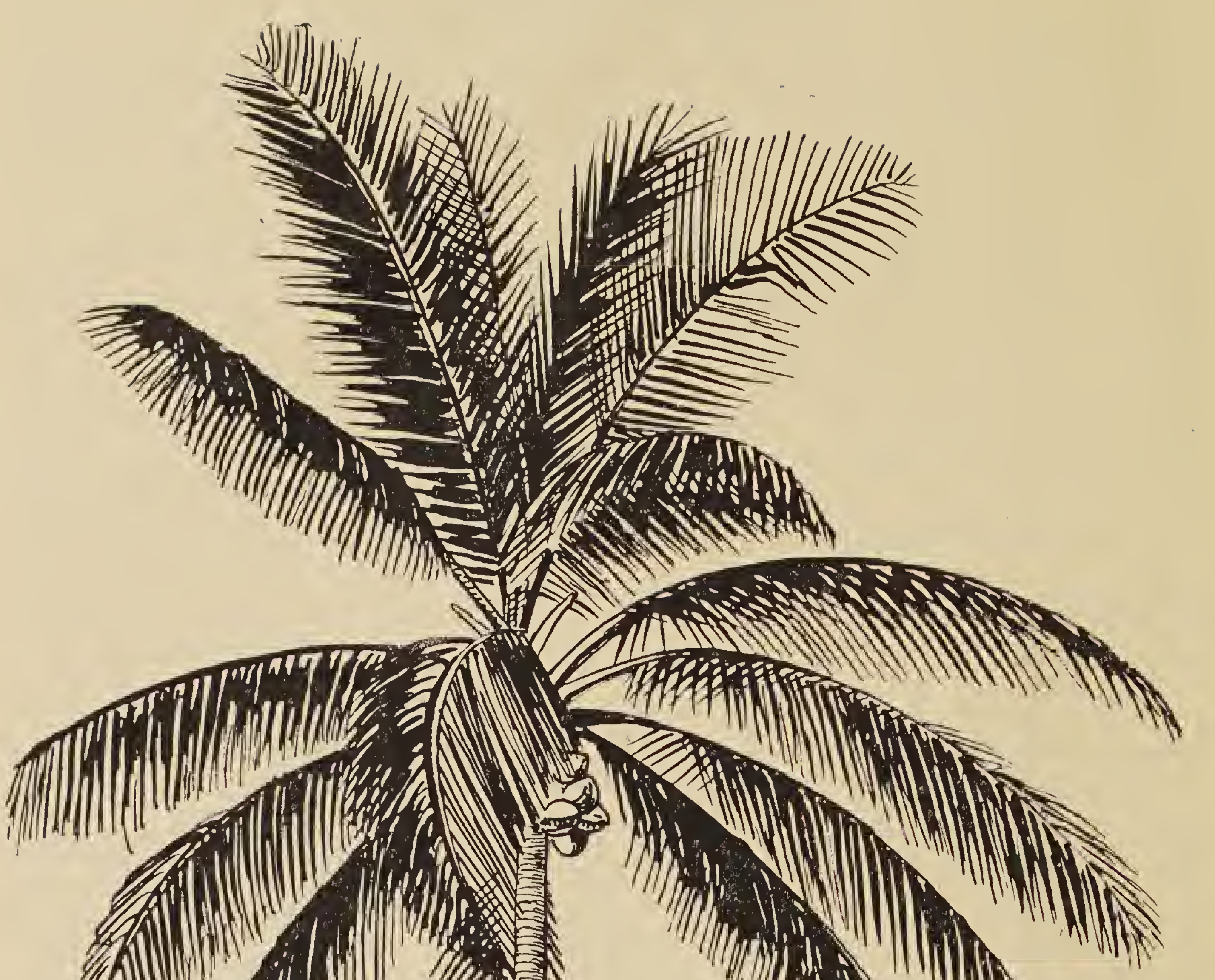
COCONUT PALMS (*Cocos nucifera*).

Bud-rot.

Tamil—Kuruthu azhukal noi.
Telugu—Movvu kullu tegulu.
Malayalam—Koombu cheechal.

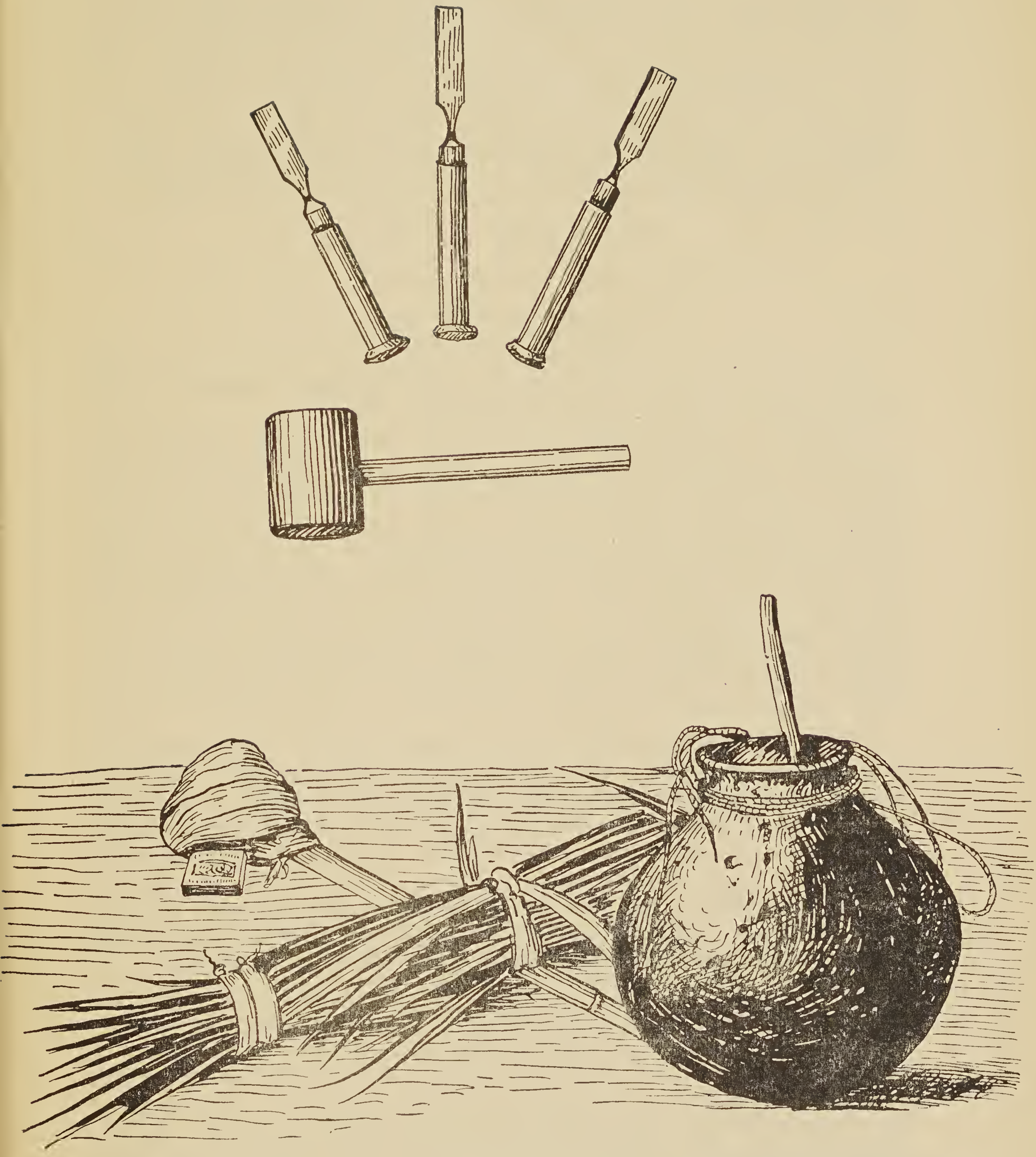
This is caused by the fungus *Phytophthora palmivora.* The two first signs by which a coconut affected by bud-rot may be recognized are (1) the central expanding leaf turns pale yellow and dries up and (2) one or more of the green leaves show discoloured spots. In the first case the central expanding leaf becomes pale yellow, falls over from its base and dies. Then one by one the green leaves surrounding it also become yellow and die. The lower leaves continue to be green for some months but they too gradually dry up and hang down. During this time the growing point dies and no more new leaves can be produced. The dead leaves keep falling off till at last the whole crown is gone and nothing is left but the bare trunk.

In the second case one or more of the green leaves have discoloured spots on some of the leaflets. If the crown of a tree in which the central shoot is dead is cut down and examined, brown spots are



Stem-bleeding disease of coconuts.

See page 42.



Things required for operations against stem-bleeding disease of coconut palms. See page 42.

seen on the leaf bases. On the surface of these spots mycelium and sporangia of the fungus are noticed. The inner parts of the bud become soft and rotten and have a bad smell. Then soft rot sets in which causes the leaf tissue surrounding the growing point to become soft and rotten. If the bud is not killed and disease spots are found on leaves, the trees can be saved by cutting off the affected leaves and leaf sheaths leaving the healthy bud. Then the tree puts forth new leaves and grows to its natural size once again. If the bud is dead the crown should be cut down, split into pieces and burnt to prevent the disease from spreading on to the other healthy trees.

The disease occurs in Godavari, Kistna, Malabar and Cochin.

COCONUT (*Cocos nucifera*).

Stem bleeding disease.

Tamil—Sar ozhukal noi.
Telugu—Lakka uragadam.
Malayalam—Rakta kari roga.

The stem-bleeding disease of the coconut palm is caused by the fungus *Thielaviopsis ethaceticus Went.**

The first indication that a tree is diseased is the exudation of a dark reddish-brown fluid from the cracks usually found on the stem. This fluid is reddish-brown at first and turns black as it dries on the bark. Behind the bleeding portion of the bark, the tissue is found to be decayed and has a yellow-brown colour. In the early stages of attack the discolouration and decay of the tissue is localized. In the later stages when there are more than one bleeding patch seen on the surface, the decay is not localized but there is a general decay of the internal tissue. When the disease reaches that stage, the tree ceases to bear nuts, the crown diminishes to a few stunted leaves and finally the whole tree dies.

On young trees the effect of the disease is at its worst, especially if the attack is at the base. In such cases, the external patches give no indication of the extent of the internal decay generally. The soft tissue inside rots and a cavity is formed in the central portion of the stem. There is an accumulation of some thin yellowish fluid which gushes out when the cavity is opened. If the decay happens to extend downwards, the tree becomes hollow without any external signs of decay. There is no treatment in such a case except to dig up the whole tree, carefully remove every bit of the roots and burn them on the spot.

The progress of the disease seems to depend upon the age of the tree. If the infection is localized, removal of the diseased parts is the cheapest and most effective remedy. The diseased parts of the coconut stem should be completely cut out and even a little more of the healthy tissue, say, about one inch, to make sure that all the diseased tissue has been removed. There is no difficulty in determining how much must be cut out since the decayed tissue which is yellowish-brown can very well be distinguished from the surrounding healthy tissue which is flesh coloured. The best instrument to use is the ordinary one-inch chisel. The decayed tissue cut out should be collected and burnt at once. The cut portion thus exposed should be tarred immediately after cutting. As tar does not adhere well to a wet surface, the cut portion should be scorched or dried with a torch made up of a small bundle of dried coconut leaves. The tar is then applied hot, and this secures a penetration of the tar to some depth inside the tissues.

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* Identical with Thielaviopsis paradoxa.

This disease has been noticed in almost all parts of the Presidency where coconut palms are grown.

Fruit-rot and fruit-fall (Mahali disease of coconuts).

This is caused by the fungus *Phytophthora omnivora var Arecæ.* The disease causes the nuts to rot and drop off from the bunches. The symptoms of this disease are similar in both arecanuts and coconuts. It has been found to appear usually in the month of August after the heavy south-west monsoon. In years when the mahali disease of arecanuts is very severe, coconuts also suffer.

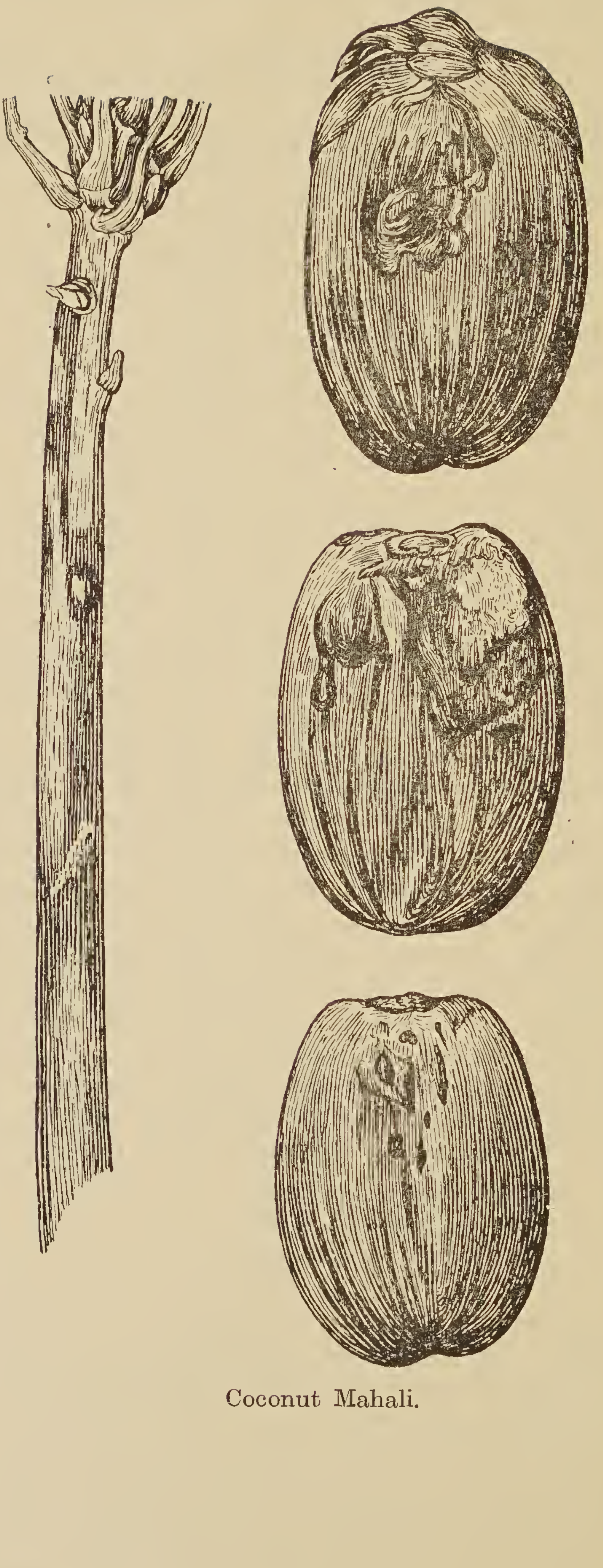
A large number of young and mature coconuts are found dropped down at the foot of the trees. The fallen nuts are found to be of dark brown colour at the base. In some cases this discolouration is seen to spread over half the surface of the fruit. On cutting open a diseased nut the husk is found to have become soft. The kernel is rotten giving out a very bad smell. The milk of the coconut is also turned brown and gives a disagreeable odour. Sometimes the stalks of the fruits get soft and rotten and the young coconuts drop off from the bunches. The surface of the diseased nuts is covered by a white mass of mycelium and sporangia. During the rains the sporangia produce zoospores and these spread from tree to tree and from bunch to bunch in rain drops blown by wind. This disease has been found to be serious on coconuts where they are grown with arecanuts and when the latter suffers very badly from mahali disease. This disease is known to pass from arecanuts to coconuts under favourable conditions of weather. In gardens where arecanuts are sprayed with Bordeaux mixture at the proper time the coconuts are not affected.

Mahali disease of arecanuts is effectively checked by spraying the bunches with Bordeaux mixture. The same treatment is equally effective in the case of mahali disease of coconuts also. All the diseased nuts and rotten fruits, stalks and flowering bunches should be removed before the monsoon sets in and burnt and the new bunches should be sprayed with Bordeaux mixture. While arecanuts are being sprayed, the coconuts may also be sprayed. As the rains are heavy an adhesive substance (i.e.) resin boiled with soda is added to make the mixture stick well to the bunches of nuts.

This disease is prevalent in Malabar.

Shoot-rot.

This is caused by the fungus *Glœosporium sp.* During the heavy monsoon rains of July and August it begins to attack the tips of young leaves. Under favourable weather conditions the attack spreads to the whole central shoot when it is often confused with bud-rot. It can be distinguished from the latter, in that the rotting commences at the tip of the unopened leaves and gradually proceeds downwards, while in bud-rot the trouble begins at the base of the bud. The progress of the disease in mature leaves is very slow, but in tender leaves it is fairly rapid. In rainy weather the affected portions



Coconut Mahali.

See page 43.

become soft and rotten, sometimes producing a stinking odour. In severe cases the trees are killed. When the weather becomes hot and dry the rotten portions dry up, curl and fall off, leaving the mid ribs more or less skeletonized. This is noticeable particularly towards the distal half of the fronds. When a number of fronds are affected the trees cease to bear.

The fungus causing the disease is a weak parasite which ceases to do damage in normal weather. Even during very rainy weather plants in robust growth were observed to shake off the disease as soon as the infected shoots emerged from their sheaths.

The treatment should be restricted primarily to the removal and destruction of the infected portions of the shoot and give a coating to the wounds of an antiseptic like Bordeaux mixture or tar. When the disease is detected in its early stages, loosening the sheath to facilitate the emergence of the shoot and its exposure to light and air was found to be a simple device which effectively checked the progress of the rot. Early detection of the disease was of immense value in that it obviated the necessity to cut off a number of young leaves, since such wholesale cutting produced a serious set-back on the growth of the trees.

The disease is known to occur in Malabar and Cochin.

Manurial experiments at the Coconut Research Stations indicate that heavy Potash manuring makes the trees more resistant to the disease.

CHAPTER VII.

OTHER CROPS.

GROUNDNUT (*Arachis hypogœa*).

Tikka disease.

Tamil—Karum pulli noi.
Telugu—Nalla matsa tegulu.

This disease is caused by the fungus *Septoglœum arachidis.* It appears when the plants are from one to two months old. The lower leaves are first to be attacked. Dark spots surrounded by a bright yellow ring come out in large numbers on the under surface of green leaves. A few such spots occur also on petioles and stem. The number of spots on a single leaf may be from one to a dozen or more and their size from one-tenth to one-third of an inch in diameter. The remaining portion of the leaf slowly looses its green colour and before this is far gone, the leaf falls to the ground.

This shedding of the leaves at the growing season of the crop is the most striking feature of the disease. After the disease has been in progress for a week or two in the field, affected plants can at once be recognized by a large number of leaves fallen round the base of the plants. The centre of the dark brown spot is occupied by a number of dark coloured spots which show a powdery appearance. This is due to the loose mass of spores with which they are covered. These spores are 2 to 4 celled, dark-brown and being very light are readily blown about by wind.

Remedy.—Introduction of disease-resistant varieties.

Wilt.

This disease is caused by the fungus **Rhizoctonia sp.* Green gram, black gram, cow pea, sunnhemp, gingelly are some of the plants attacked by this fungus.

Conditions favourable to the disease.—If the plants are grown under damp conditions and are crowded they are often attacked. The attack is most severe in the seedling stage during continued rainy weather, when the disease spreads with great rapidity and takes on an epidemic character.

Symptoms of disease.—The first appearance of this disease is the discolouration of the stems just above the surface of the soil and the permanent wilting of the leaves. The stem rots at the affected portion and the plants fall over to one side. In later stages, on the decaying stems and leaves whitish masses of fungus are seen. Later, when the tissue attacked is old, the bark gets shredded into fibres and dark-brown thick-walled round bodies known as ‘ Sclerotia ’ of the fungus are found in the rotten tissues. The tissue is first covered by a dense white fungus mass (mycelium), and later soft whitish round bodies (sclerotia) appear in this mass. These round bodies soon turn brown and get hardened. They are of varying sizes. They are usually the size of a small pin head. They lie in the ground along with the decayed tissue and are known to retain their vitality for a very long time. They are easily carried from place to place by various agencies, such as insects, cattle, farm labourers and implements. They are also found inside the pod and on the surface of the kernels. Under favourable conditions of weather and moisture these bodies start their growth and attack such crops as are susceptible to their attack.

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* *Rhizoctonia bataticola.*

Mode of infection.—The fungus gains entrance into the plant at the surface of the soil, attacking first the base of the stem. Sometimes in the case of plants of spreading habit like the groundnut touching the ground, young leaves in contact with the soil get infected. Another mode of infection is by diseased parts of plants falling over and touching healthy plants. When infection takes place in this way it generally starts at the leaf tips and spreads to tender stems and even to the more mature stems. Injury to stem and leaves is not necessary for infection as the fungus is able to penetrate through unbroken epidermis.

Methods of dealing with this disease.—Liming the soil, before sowing, at the rate of 1,000 lb. per acre has produced beneficial results. Deep ploughing seems to exert a satisfactory influence in the control of the disease by helping to bury some of the sclerotia of the fungus at lower depths where they are rendered incapable of infecting the plants. With regard to varietal resistance, none of the varieties show any immunity but there is difference in the degree of resistence. Sowing of disease-free seed is essential.

Clump disease.

The disease appears in the irrigated crop and affected plants are characterized by a dense clump of tufty dwarfed shoots with yellowed leaves and the plants stand erect instead of spreading on the ground. Such plants stop growing after a time and bear very sparingly. From the peculiar habit of the affected plants, the disease has been called ‘ Clump ’ disease. Only individual plants or a few in localized patches exhibit the disease, while others quite close to the affected ones are quite normal in their habits and bear well-developed pods.

The diseased plants were examined in detail and sections taken from different parts of the plant failed to show the presence of any causative organism. From the nature and appearance of the disease, there is no proof that the disease is transmitted through soil. To see whether the disease was transmitted through seed, apparently well-developed seeds from diseased plants were collected from the station and were sown in pots. The plants raised from these seeds were normal in habit and did not develop the disease.

Observations made during succeeding seasons show that the disease is not confined to any particular variety, and has appeared in all the twenty varieties raised at the Palakuppam Agricultural station.

The following varieties of groundnuts have been observed to be the worst victims of the disease:—

(1) Barbados Ceylon, (2) Carolina, (3) Local Mauritius, (4) Mauritius Mauritius, (5) Senegal, (6) Transvaal, (7) Virginia bunch, (8) Virginia runner, (9) Virginia Mauritius, (10) West African.

Remedy.—Roguing out diseased plants may help to check the spread of the disease. But pending further investigation no definite remedial measures are suggested.

It has been noticed in the South Arcot district.

CHILLIES (*Capsicum frutescens*).

Die-back and fruit-rot.

Tamil—Milakai azhukal noi.
Telugu—Mirepa kaya kullu tegulu.
Malayalam—Milaku cheechal.

This disease is caused by a fungus * *Vermicularia capsici.* This is worst in the months of November and December where there is heavy rainfall. When drier conditions prevail the virulence of the disease is abated.

This disease attacks the fruits causing them to become soft and rotten. In the later stages the fruit turns yellow, dries up, loses its pungency and becomes useless for consumption. The loss is very serious and it sometimes amounts to one-third of the whole crop.

On the surface of the rotten fruits small black spots can be seen. In these spores of the fungus are found. They are produced in very large numbers and are easily blown off by wind from field to field This disease is also noticed on the stem and leaves of young plants causing leaves to fall off prematurely. The young branches lose all the leaves, die-back and stand bare.

The best way of reducing the damage caused by this disease is to spray the plants early in the season with Bordeaux mixture when the disease makes its appearance on the leaves and stem and again when the fruit forms.

To prevent the disease from appearing in the next crop, the following precautionary methods may be followed:—

(1) After the crop has been harvested, all the plants in the diseased field should be gathered and burnt in the field or used as fuel. Do not let them lie and rot in the field.

(2) Chillies should not be planted again in a diseased field for at least two cropping seasons.

(3) When choosing seed for the next crop, it should be got from a place in which the plants were quite healthy even if a little more has to be paid for it.

(4) Seed should not be used from the produce of a diseased field.

(5) Vegetables like brinjals, tomatoes and ladies finger (*Bendai*) should not be grown successively in these fields as these are also attacked by this disease.

(6) Weeds as *Solanum nigrum*, *Withania somnifera* which harbour this disease during the off season should be eradicated.

The disease is known to occur in Coimbatore, Salem, Trichinopoly, Malabar and Guntur.

GINGER (*Zingiber officinale*).

Leaf-spot disease.

Tamil—Pulli noi.

Telugu—Matsa tegulu.

This is caused by the fungus *Vermicularia Zingiberæ.* The disease shows itself by the formation of light yellowish spots both in the upper and lower surfaces of leaves. They are at first very small and gradually increase in size. The portion of the leaf attacked dries

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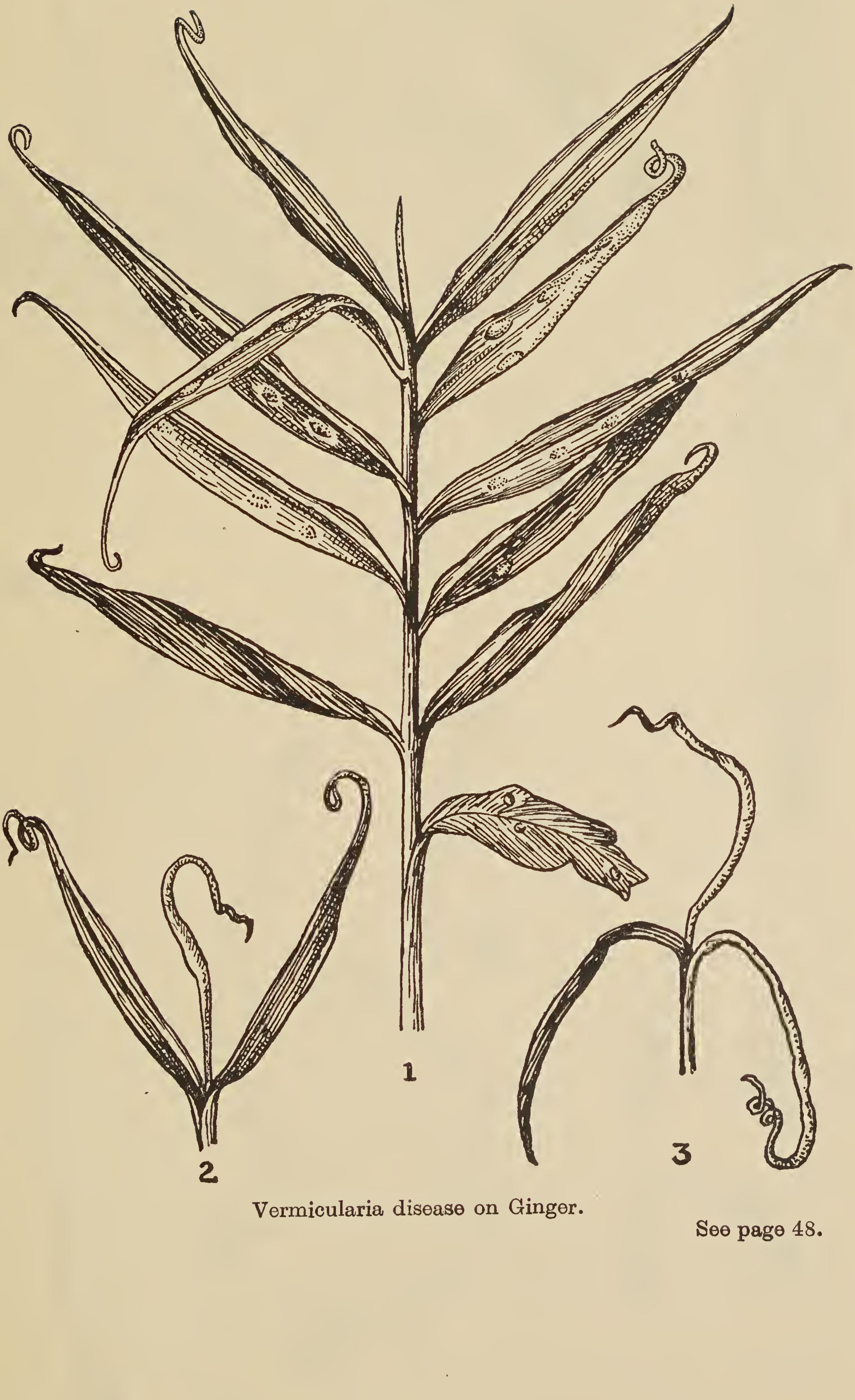
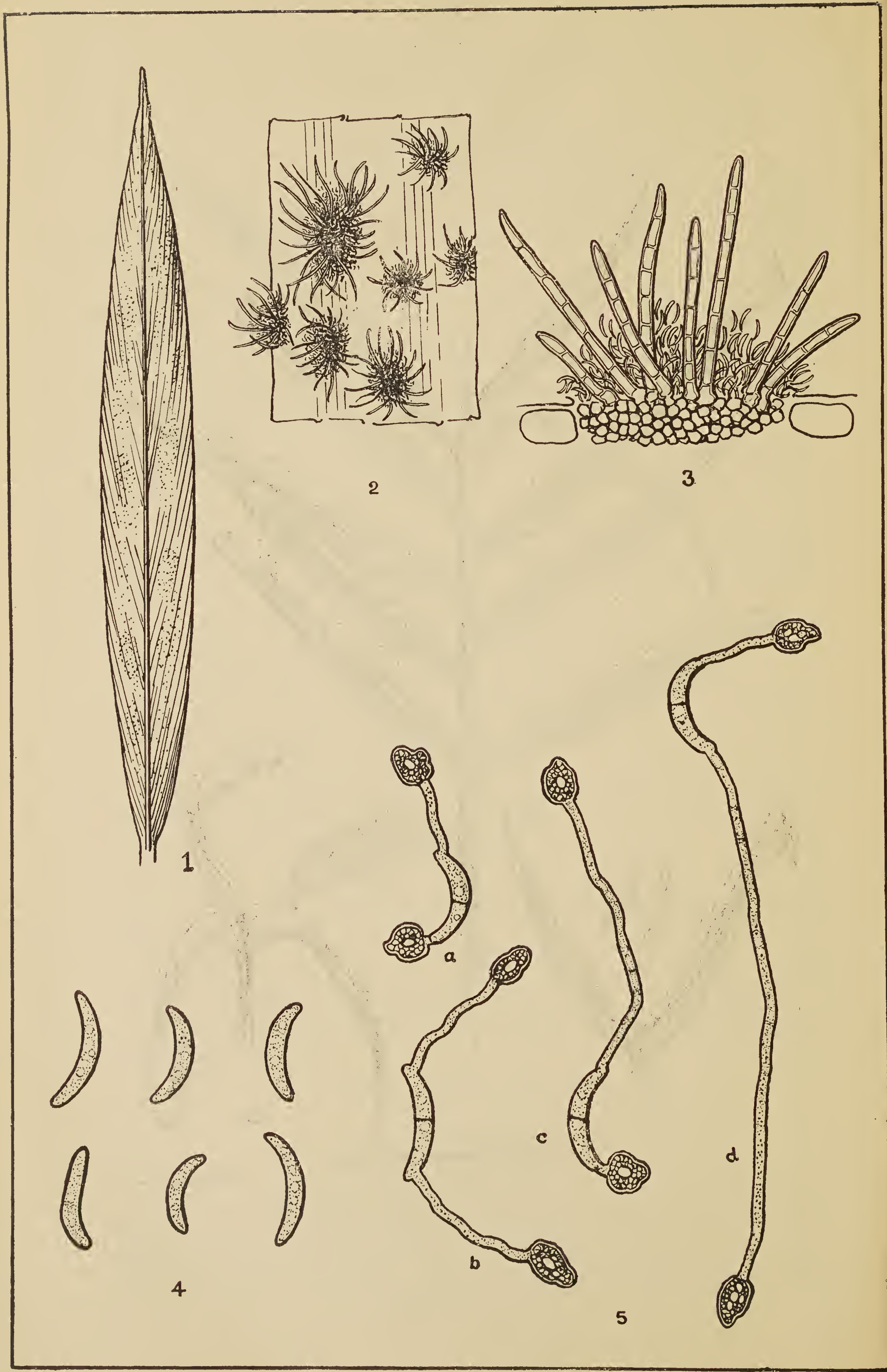
* *Colletotrichum capsici.*



Vermicularia disease on Ginger.

See page 48.



Vermicularia disease on Ginger. See page 48.

up and holes are formed. Sometimes the entire leaf gets the disease, rots and dries up. The disease appears during the rainy weather and appears in an epidemic form in the years of heavy rainfall. The disease spreads from leaf to leaf and from plant to plant in rain-drops blown by wind. Very often the cultivator, through ignorance, produces conditions favourable to spread this disease, by thick planting which tends to make the plants touch one another.

Effect of the disease on the crop.—The disease appears on the leaves. This is the place where the plants manufacture food. The disease makes its appearance in the growing period of the crop and at a time when the rhizomes begin to develop. The plants get stunted and the rhizomes do not develop. Under healthy conditions the crop stands on the ground from July to March but when the disease comes on, the crop is lifted early before the plants begin to die.

How to check this disease from spreading.—All the badly affected leaves and shoots should be cut out and burnt. The other healthy plants should be sprayed with Bordeaux mixture. Two sprayings at intervals of a fortnight will check this disease from spreading. The usual practice in certain plantations has been to sprinkle quicklime on the affected plant and this has been reported to check the disease to a certain extent. This disease has been found in several ginger growing tracts in the Amalapur taluk, Godavari district.

Soft-rot.

Tamil—Azhukal noi.
Telugu—Kullu tegulu.
Malayalam—Cheechal rogam.

This is caused by the fungus *Pythium butleri.** The first outward indication of the disease is a general but slight paleness of the leaves of a shoot, followed by yellowing of the tips of the leaves. This yellowing gradually spreads down the leaf to the leaf sheath, often more rapidly along the margins. Behind it, the leaf progressively withers and dies, and ultimately hangs drooping from the sheath. Then the whole shoot dries up. Meanwhile the base of the shoot between the rhizome and the surface of the soil turns a pale, translucent brown colour, and by the time that the leaves are well yellowed, it is very watery and soft, so that the whole shoot can easily be torn off from this point, though it rarely falls over spontaneously. The soft-rot also extends beyond the collar into the rhizome, which is discoloured and gradually decomposes, forming a watery mass of putrefying tissue enclosed by the tough rind. In this mass the fibro-vascular strands lie isolated. The roots arising from the affected parts present in general the same symptoms. Once the disease becomes established, no new rhizomes are formed.

All the diseased parts below ground, base of the shoot, rhizome and roots contain the mycelium of the fungus and in advanced stages oogonia (thick walled resting spores) of the fungus are formed.

Preventive measures.—At harvest all rhizomes should be lifted. Diseased ones must be carefully collected and destroyed with as much of their roots as possible.

Ginger should not be grown again on the same land for several years.

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* Pythium aphanidermatum.

Seed should be got from a place free from disease, and should be carefully hand-picked and all diseased ones discarded.

Whenever disease occurs, the affected plants should be dug out whole with the larger roots and burnt. Pulling out is not satisfactory, as the rotted parts break off easily.

Good cultivation, and especially drainage, is of great importance, as is also the choice of suitable soil. Light sandy loam and loam that is well drained are the best. In heavier land, great care is necessary to avoid the accumulation of water in the upper layers, and the consequent increase in growth and reproduction of the fungus.

TURMERIC (*Curcuma longa*).

Leaf-spot disease—Rhizome-rot.

Tamil—Pulli or Poriyan noi
Telugu—Lambadi tegulu.
Malayalam—Pulli roga.

This crop is subject to a leaf disease (*Vermicularia curcumæ*) which checks the growth and development of the rhizomes. This disease makes its appearance on the plants when they are nearly four months old, i.e., in August and September. The leaves are the first to be attacked, later on the infection spreads to the leaf sheaths and finally the rhizomes succumb. In the beginning small yellowish spots appear on the surface of leaves. These gradually increase in size spreading sometimes over a larger portion of the surface. Sometimes the whole crop is affected and it withers and dies. On the surface of the dried up portion small black spots are seen to appear. These are the spots where the fungus produces spores. These are very minute and are produced in very large numbers. They are easily blown off by the wind or distributed in rain drops blown by wind. Thus the disease spreads from plant to plant and from field to field. A badly affected field looks as if the leaves were scorched up by fire. It has been found that spraying with Bordeaux mixture in the early stages of attack checks the disease and prevents its spread, thus saving the crop. It has been observed that the disease lurks in the seed turmeric kept for the next year's sowing. If this is sown the crop that comes next will get this disease. Therefore care should be taken that seed from the diseased field should not be used for planting, but healthy seed should be obtained from localities where there is no disease.

It is known to occur in Coimbatore, Godavari and Kistna.

BETEL-VINE (*Piper betle*).

Wilt.

This disease is caused by the fungi *Phytophthora sp.* and by *Sclerotium rolfsii.*

In the disease caused by Phytophthora the leaves suddenly lose their turgidity, become flaccid, droop, turn yellow and the plant dries up in the course of a week or less. An examination of the collar region of a dying vine will show dark water-soaked spots which get softened resulting in the rot and complete shredding of the stem. The fungus enters into the healthy stem and eats into the tissue as a result of which the stem disintegrates and dies.

The second disease is caused by *Sclerotium rolfsii.* It is found mostly on the underground coiled portions of the stem and is characterized by the presence of a thick white weft of mycelium which completely envelops the base of the plant. The affected portion of the stem rapidly rots and gets shredded. The connexion between root and stem being thus severed the plant dies.

Control measures.—Both the fungi which cause the death of vines are soil dwellers and develop only in the presence of plenty of moisture. Though the cultural practices adopted by the vine-growers have been developed to a high degree, there are certain weak points in them which make the spread of such diseases inevitable. Firstly, one betel crop is as a rule followed by another betel crop on the same land. This enables the latter fungus to flourish unimpeded year after year on the betel vine on which alone it can live. If betel vine is rotated with a crop like paddy or sugarcane, the fungus will be starved for want of a suitable host plant to live on and the chances of reinfection when a second crop of vine is raised, are limited.

Secondly, the fungi being water-loving organisms, drainage is an important factor in their control. Only the minimum quantity of water that is essential for the growth and bearing of the vines should be used and the trenches should be drained as dry as possible. During the close of the north-east monsoon when the water-supply from the irrigation channels is not abundant, it is the practice among the cultivators to flood the trenches and store water in them for irrigation. This is a very faulty practice inasmuch as it prevents the drainage of the soil and encourages the development of the disease-causing fungi.

In both cases infection spreads from the ground. Spraying of the collar regions of the vines and drenching the soil with a fungicide like Bordeaux mixture may be tried. At the same time advice is given to keep the garden from overflooding and to try simple remedies such as liming the soil, lopping off agathi branches to let in more sunlight, and practise a more judicious rotation.

This disease occurs in the Chingleput district.

POTATO DISEASES.

The Early Blight.—This is caused by the fungus *Alternaria Solani.* The early blight is confined to the leaves and stems. It begins to show at the time when the young tubers are formed. Small light-brown spots with well-defined edges appear on the leaf in crescent size and darkened in tint. Faint concentric rings mark the successive edges of the spot. This is a sign which distinguishes early blight from Irish blight or late blight in which the spots are not so marked in this way and the edges of the spot are not so well-defined. The spots become dry and brittle. They gradually spread over the surface covering most of the leaves, when, the leaves and shoots collapse and die. The fungus does not apparently enter the tubers. The fungus causes the shoot to die before it has produced enough food-material for the development of the tubers which accordingly remain small. The spores of this fungus appear on the spots. A few conidio phores (stalk of conidia or spores) project from a stoma and each bears a many-celled spore. The fungus which causes this disease does not cause a rot in the tubers. What the fungus really does is to destroy the green leaves that manufacture the food which is to be stored in the tubers. The early death of the leaves stops the manufacture of food and leaves the potato small and causes a shortage of crop. Spraying with Bordeaux mixture reduces the injury done by this fungus very much.

Irish Blight or Late Blight.—This is caused by the fungus *Phytophthora infestans.* This attacks the leaves, stems and tubers. The spots in the leaves are irregular in their outline, soft and watery in texture, sometimes with a faint grey appearance due to the presence of mycelium. The spots spread rapidly over the leaves and stems which become moist and flabby and in a few days the plant is reduced to a blackened putrefying mass with a nasty smell. The spores on the leaves fall on the ground and are washed into the soil. Some of them come in contact with potato tubers which they penetrate just as they do the leaves. It may also pass down the diseased stem. The fungus in the tubers causes a dry rot. It destroys the substance of the potato and renders it liable to rot caused by the bacteria and moulds. Sometimes the potatoes rot in the fields and sometimes in the store room. There are means of control. Potatoes should be stored in a cool dry atmosphere. Greatest care should be taken not to plant potato seed which have a soft part outside. In places where this disease occurs every year, the damage it causes has been reduced to a minimum by the application of Bordeaux mixture.

Ring disease.—Caused by *Bacterium solanacearum.* In the field, single plants and groups of plants show signs of wilting, i.e., the shoots and leaves suddenly become soft and limp and hang down. On slicing the tubers of the infected plants, small dark spots may be seen forming a ring a short distance inside the skin, in the region of the vascular bundles. A cross section across the collar of the stem (that part of the stem just above the roots and near the ground level) shows a similar discolouration. In the vascular bundles the water conducting tubes and vessels and the adjacent cells are seen under the microscope to be filled with masses of bacteria. These choke the water conducting tubes (just as sand does in a drain pipe) and cut off the supply of water to the green leaves which immediately droop and hang down just as cut flowers do if not placed in water. For ring disease, spraying is of no use. Carefully collecting and burning all infected parts, and removing all rotten ones at the time of harvest is necessary. Rotten potatoes left in the ground carry on the bacterium which can live in the soil for more than one year. In planting potatoes, do not put them in a field where the disease has occurred for at least two years. As it is not always possible to detect early stages of infection with naked eye, seed potatoes should not if possible be taken from a field where this disease has occurred.

Potato Scab.—Brownish, reddish or yellowish spots appear with a scab-like surface which may be deeply cracked or furrowed. The fungus causing the scab eats into the surface of the potato and destroys it. All seed potatoes that have warts or scabs should be discarded when sowing. A very slight wart on the surface can be destroyed by steeping the potatoes in formaline or corrosive sublimate solution. To grow properly, this crop must be rotated with others. The importation of seed from other places is to be encouraged, but it must be done intelligently and carefully.

COTTON DISEASES.

In South India, cotton is fortunately free from some of the more virulent diseases that cause considerable damage to it in other parts of the world. The practice of systematic rotation prevalent in many cotton districts and the removal of the entire plant from the field after the harvest, are no doubt to a great extent responsible for this comparative freedom of the cotton plant from fungus diseases.

Wilt.—The 'wilt' in South India is caused by *Rhizoctonia bataticola*, a fungus which attacks various other crops besides. The disease is seldom serious except when it attacks the crop in the seedling stage when the seedlings may be killed outright.

Symptoms.—* "Infected seedlings usually show a soft yellow patch on the lower portion of the stem, when the attack occurs while the seedlings are very young and the stem soft. In slightly older seedlings when the stem is harder and more woody it becomes blackened at ground level. In bad cases the rot is enough to cause tender seedlings to collapse while older ones dry up and wither as if for want of water." The fungus is seldom able to attack full grown plants unless the conditions are extremely favourable for it. The fungus persists in the soil for a long time, but rotation of crops, good cultivation and proper drainage will keep the disease under control.

'Seedling Blight' and 'Boll-rot'—(Coimbatore).—The disease is caused by a fungus *Colletotrichum* spp. (?). The disease resembles the well-known 'Anthracnose' but it differs from the latter in several important details. The disease appears during two stages of the crop, namely, the seedling stage and the fruiting stage. When it occurs in the seedling stage it causes damping off of the seedlings. The fungus attacks the cotyledons and the hypocotyl. In rare cases the first foliage leaves are also involved. On the cotyledons, spots are formed while on the stem a blackening accompanied by a shrinkage of the tissue is caused. If weather conditions are favourable for the spread of the disease, the seedlings die, but if dry conditions prevail the progress of the disease is checked.

Seedlings which survive the attack exhibit a condition known as 'sore shin' which is but a healed up 'canker' of the stem. The disease spreads rapidly in wet weather, but its virulence is considerably abated in bright sunny weather.

'Boll-rot.'—The fungus attacks the bolls in all stages of development. The disease appears on the exposed surface of the bolls starting either at the apex or base. The first sign of infection is the formation of a small pinkish brown irregularly circular spot. As the infection progresses the discoloured area extends becoming dark grey in colour with the formation of several concentric rings of black pustules. When young bolls are attacked, they cease to grow, get hardened and fail to burst. The lint inside gets lumped and is stained yellow. When partially mature bolls are attacked, they burst normally but the lint is rendered brittle and does not protrude from the locks. Black pustules develop on the kapas and within the lint. Seeds formed within infected bolls are generally poorly developed and

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* E. J. Butler: Fungi and Diseases in Plants.

show poor germination. The study of the life history of this fungus has shown that the fungus is capable of hibernating within the seed coats of apparently healthy seeds.

Climatic factors.—The disease appears in epidemic form during prolonged rainy weather, the damage depending on the extent of the period during which wet weather prevails. With the return of normal sunny weather, the fungus stops development and fresh attacks cease to occur.

Control.—The disease is confined to Herbaceum cotton (Uppam). The disease is carried through seed and great care should be exercised in selecting disease-free seed. Seeds from diseased bolls should be avoided. If the disease appears during the seedling stage and weather conditions are favourable to its spread, one or two sprays of Bordeaux mixture keep it in check. The same operation may be carried out with satisfactory results in the fruiting stage also.

The fungus causing this disease has been observed to occur on leaves, petioles, stem and fruits of *Aristolochia bracteata*, a common weed of the black cotton soils in Coimbatore when the cotton crop is off the ground. There is therefore little doubt that this is one of the sources by which this fungus is carried over from crop to crop.

Macrosporium leaf-spot.—The fungus appears on the cotyledons of seedlings and should favourable conditions exist it spreads to the foliage leaves causing their shedding. The disease has been observed in Cambodia, Uppam and Karunganni.

Remedial measures.—Spraying with Bordeaux mixture controls the disease but the disease is seldom serious enough to warrant control measures.

Areolate mildew.—*Grey mildew* caused by a fungus *Ramularia areola* is a disease of very minor importance. *" It occurs chiefly on older leaves as the plants reach maturity in the form of irregularly angular, pale, translucent spots (3 to 4 m.m.) in diameter and with a definite margin formed by the veins of the leaf. As the spots grow older the leaf tissues turn yellowish brown while a *whitish* frosty growth appears chiefly on the under surface but occasionally also above."

CASHEWNUT (*Anacardium occidentale*).

Die-back (*Pink disease*).

The disease is caused by the fungus *Corticium salmonicolor*. It is characterized by the branches dying and drying up, presenting a stag-head appearance. In the early stages the leaves of the affected branches and the twigs lose their green colour, wither and dry up.

On examining these branches closely, a light pinkish coating is noticed on the dried portions of the stem. The pinkish encrustation extends and covers very often the entire circumference of the stem causing ' ring-barking ' and consequent drying up of the entire branches in course of time. The bark is found to dry up, crack and peel off in flakes. In the early stages of attack a whitish coating of fungus is seen on the bark which appears as if covered with a light whitewash. The progress and spread of the disease depends upon conditions of moisture prevailing at the time. The amount of damage depends upon the age of the trees. Young trees about two to three years old are easily susceptible. On older trees the drying up is confined to the upper branches. Young stems are quickly encircled and ringed. This takes place during the monsoon periods. With the advent of hot weather the spread of this fungus is checked.

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* E. J. Butler : Fungi and Diseases in Plants.

This fungus is known to attack mangoes, oranges, jack, tea, coffee and several other trees.

Treatment of this disease.—As the fungus grows and fructifies freely on dead and drying wood, prompt cutting of dead branches and burning them are necessary. These should on no account be left lying about to rot, but collected and used as fuel. Diseased branches should be removed by cutting back until healthy portion is reached, which will be about a foot below the lowest point at which discolouration of the wood can be noticed. A sloping surface should always be left after removal. Large branches should be cut flush with the stem. A smooth surface should be left. All the wounds which expose the wood should be tarred.

This disease occurs in Malabar and South Kanara districts.

APPENDIX.

Description of a Simple Pressure Sprayer.

The sprayer consists of a reservoir, an air pump, a manometer, rubber hose, stop-cock, brass spray pipe, spraying nozzle, straps and funnel with strainer.

To the top of the reservoir four things are attached:—

(1) The circular opening through which the liquid is poured into the vessel is closed by a screw cap (11) to which is fitted a small movable lever to facilitate tight screwing.

(2) The air pump consists of a copper tube (6) within which is a piston rod (5) to which the piston head (3) is attached at the lower end and a handle (10) at the upper end. The lower part of the tube (6) contains a valve (2) kept in position against the lower opening of the tube by a spring (1). When the handle is pulled out as far as it will come and pressed down with vigour air is forced into the reservoir. This raises the air pressure inside.

(3) As the air pressure rises a watch-hand travels along the graduted dial of the manometer (8); when it has reached a red mark sufficient air has been pumped in to drive out the liquid contents.

(4) A small round box (7) contains vaseline to grease the piston and washers and also a spare piston-head.

When the sprayer is pumped full, the piston has a tendency to push itself up to its full length. This is inconvenient to the person using the sprayer. So a wire-hook (9) clips it down in the position shown in Plate I. At the lower end of the vessel is a small opening to which is attached in series a rubber hose (12), a stop-cock (13), a brass-rod (14) and a nozzle (15).

The nozzle, Plate II, Fig. 4, consists of seven parts screwed together to form one piece. The seven parts are drawn as figures 5 to 11 in illustration No. II, and the fitting of them together is obvious. On pressing upwards part (7) the needle (6) moves upwards into the small hole of part (5) and removes any small piece of grit that may be blocking the hole and stopping the liquid coming out as a spray.

Behind the sprayer a belt is attached to hang round the coolie's shoulder. It is, however, more comfortable to the coolie to put the sprayer in a canvas bag with padded shoulder straps.

To fill the sprayer ready for use unscrew the lid (11), push in the strainer Plate II, Fig. 22, shut the stop-cock (13) and push back the hook (9). Pour in one gallon of the liquid through the strainer, screw on the lid (11), pump in air till the watch hand travels to the red-mark and clip the hook (9) to the handle (10). The sprayer is now charged ready for spraying. Open the stop-cock (13) and a fine spray will come out of the nozzle (15).

Plate II illustrates various parts that may have to be replaced. No part need be replaced for several years except for some accident as dropping the sprayer from a height.

After spraying never put a sprayer away even for a night without being well washed, by pumping clear water through it until it is clean.

The leather washers should be well oiled and all valves and connexions should be kept tight so that they will not leak.

Copper sprayers can be used for the use of copper and iron salts, Bordeaux mixture and all other non-sulphurous spraying liquids.

Several types and sizes of sprayers are available to suit various requirements.

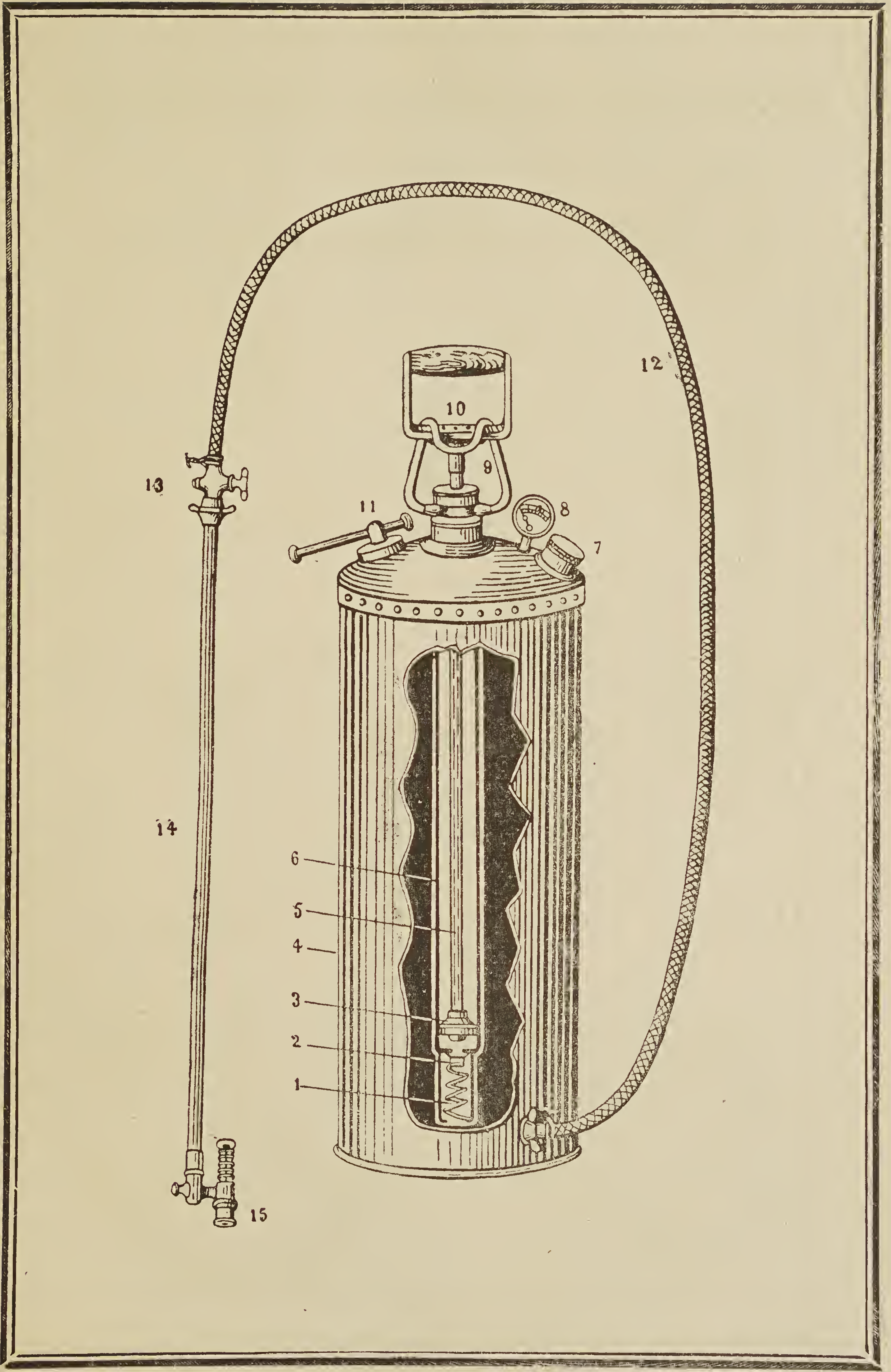

PLATE I—A pressure sprayer.

See page 58.

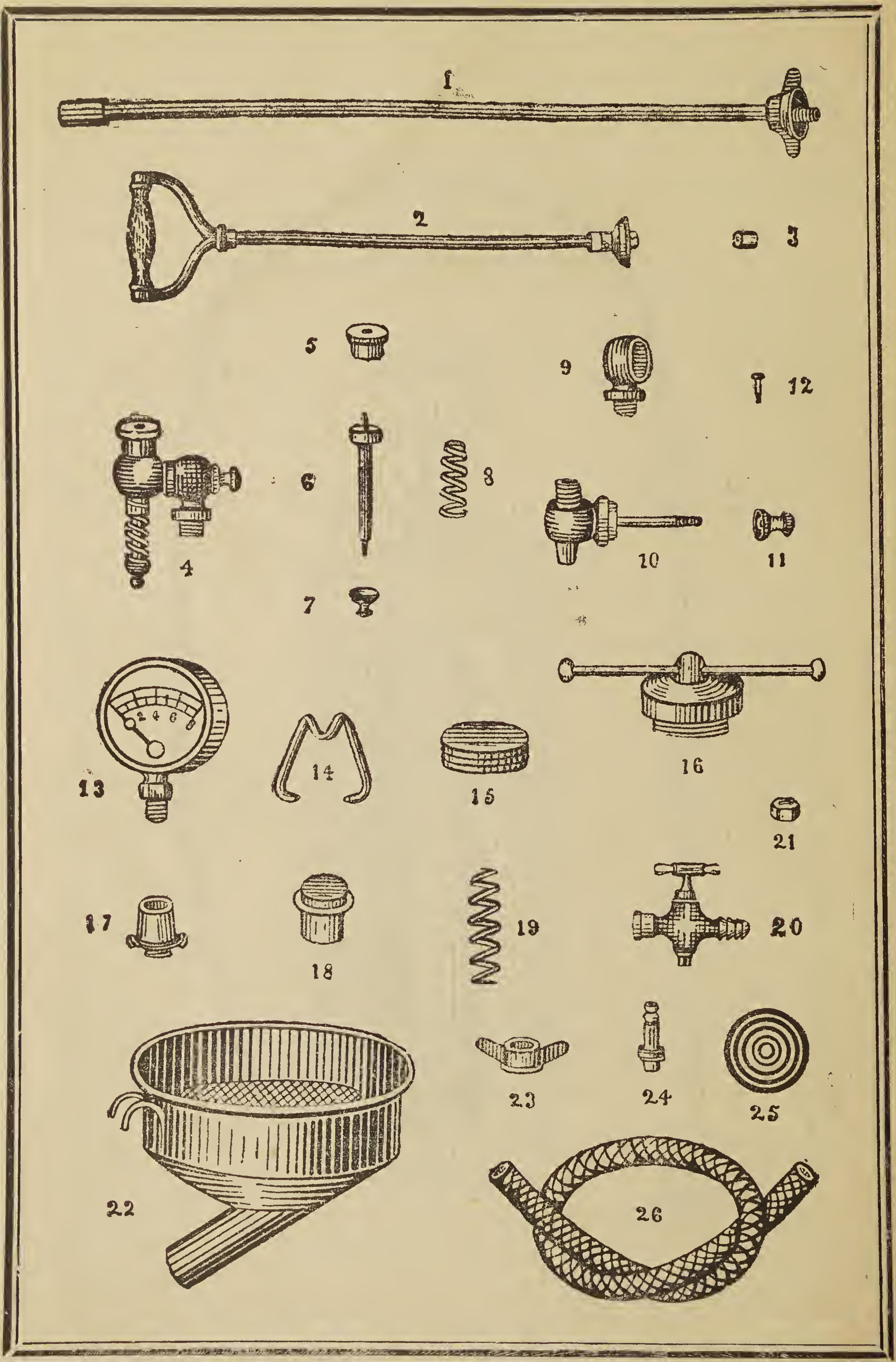

PLATE II—Parts of a sprayer.

See page 58.